CHAPTER 1

UPPER-AIR OBSERVATIONS

INTRODUCTION

In this chapter, we discuss the different types of upper-air observations in addition to the primary upper-air observation equipment used by the Navy and Marine Corps. We also discuss how to identify information in the various upper-air code forms. Finally, we discuss the TEMP and PILOT codes that are used to disseminate upper-air observation data and the records that are maintained for each observation.

UPPER-AIR OBSERVATIONS

LEARNING OBJECTIVES: Recognize the uses of upper-air observation data. Identify the different types of upper-air observations. Determine which types of upper-air observations are conducted by Navy and Marine Corps observers. Identify the publications that govern upper-air observations and observation codes.

During an upper-air sounding, special instruments measure different atmospheric elements in the lower two layers of the atmosphere. These layers are the troposphere and the stratosphere (fig. 1-1). A meteorological transmitter, known as a radiosonde, is attached to a balloon and is tracked by ground equipment. The radiosonde contains sensors that transmit pressure, temperature, and relative humidity data to a receiver as the balloon ascends into the atmosphere. Wind information can also be determined by tracking the balloon's movement via radio signal or optically. The information is processed, encoded, and then transmitted over automated weather networks. Upper-air observations are often referred to as upper-air soundings.

The National Weather Service, U.S. Air Force, and the U.S. Navy's meteorological and oceanographic forecast centers run primary upper-air forecast programs twice a day based on data received from the 0000Z and 1200Z upper-air soundings. The computer programs can use data up to 12 hours old. All observations, regardless of the observation time, are used if received within 12 hours after the observation. Additionally, all transmitted observations, even those not used in forecasting programs, are automatically entered in the upper-air climatic data base at the National Climatic Data Center in Asheville, North Carolina. This data is used extensively in atmospheric research.

Locally, upper air observations provide an immediate vertical profile of the atmosphere and are invaluable as a forecast tool, particularly for severe weather and general aviation forecasts.

NAVY/MARINE CORPS UPPER-AIR PROGRAMS

Upper-air observations are conducted aboard many naval ships and at many naval and Marine Corps stations. Aircraft carriers (CVs) and most amphibious ships (LCC, LHA, LHD, LPHs) routinely conduct upper-air observations primarily for operational support. This support includes weather forecasts as well as refractivity forecasts. Some sites located on islands or in remote areas are designated Synoptic Upper-air Observation Sites. These activities routinely conduct upper-air observations to support World Meteorological Organization (WMO) data collection requirements, as well as operational commitments. Mobile Environmental Teams (MET) use portable equipment aboard ship and at remote shore sites to conduct upper-air observations in support of operational and research requirements. Marine Corps Meteorological Mobile Facility (MMF) members also use portable equipment and meteorological vans to conduct upper-air observations to support forces on temporary deployments.

Normally, <u>all</u> upper-air observations from ships, designated Synoptic stations, and remote land locations are encoded and transmitted. Special observations conducted for training at shore stations may be encoded but are not usually transmitted.

NOTE: In this chapter, we use *altitude* and *height* only by the strictest definition: *height* is the vertical measurement or approximation above the ground level (AGL); *altitude* is the vertical measurement or approximation above mean sea level (MSL). Most

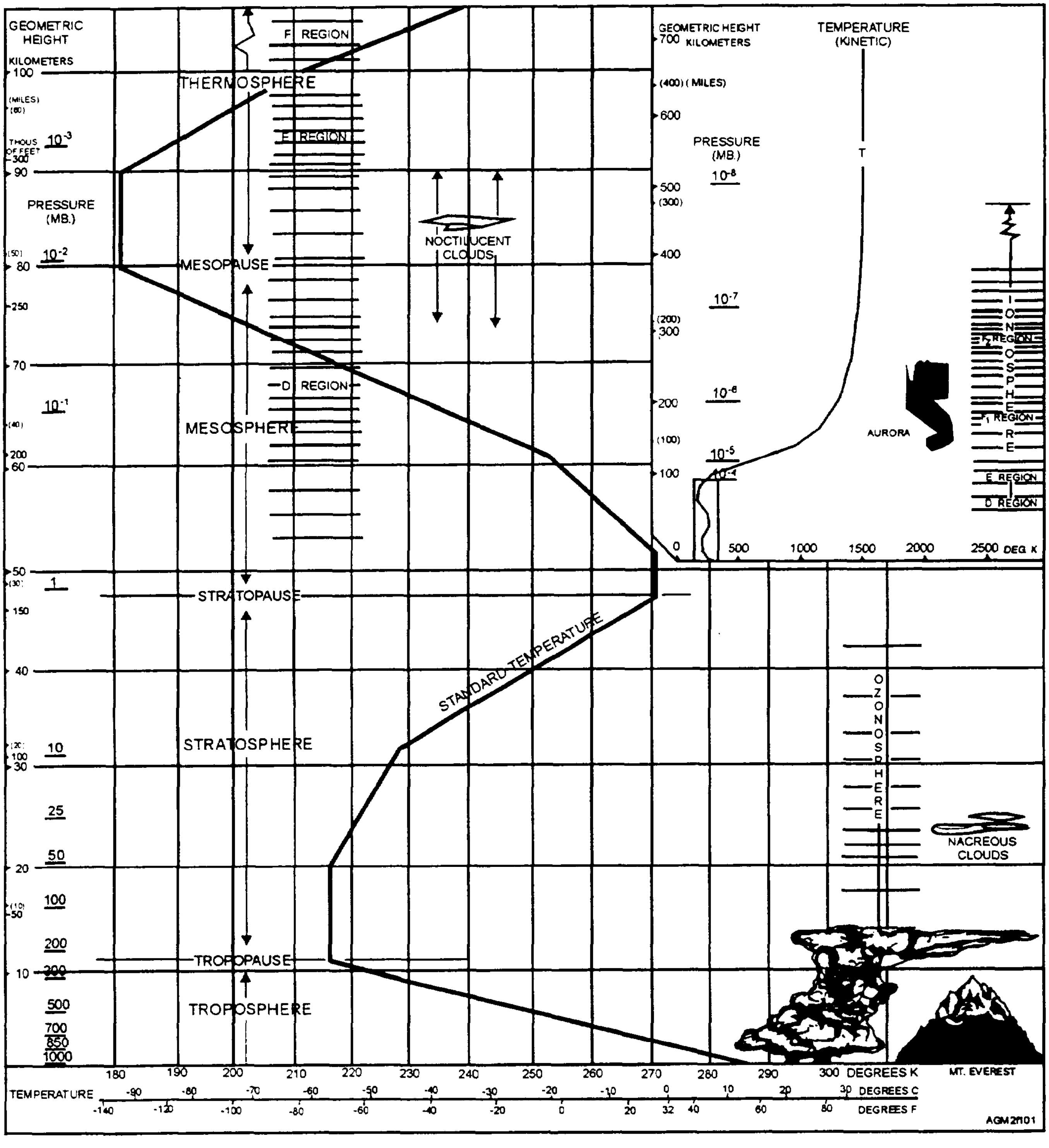

Figure 1-1.–Earth's atmospheric layers.

encoded and reported "heights" in upper-air observations are actually altitudes.

TYPES OF UPPER-AIR OBSERVATIONS

The term *upper-air observation* may be applied to any of the different types of observations conducted to measure the temperature, humidity, pressure, and/or wind speed and wind direction at various levels above earth's surface. The terms *RAOB (RAdiosonde OBservation)* and *RAWIN (RAWINsonde observation)* are frequently used to refer to type of upper-air observation. In the past, Navy and Marine Corps observers conducted several types of upper-air observations:

- *Radiosonde observations:* Pressure, temperature, and humidity measured by a balloon-borne instrument. Data is transmitted in the TEMP, TEMP MOBIL, or TEMP SHIP code.

- *Rawinsonde observations:* Pressure, temperature, and humidity measured by a balloon-borne instrument. Wind speed and direction may be obtained from a ground-based directional-tracking antenna homing in on the radiosonde's transponder. Winds are also calculated by using remote Very Low Frequency (VLF) signals or by the satellite Global Positioning System (GPS). Collected data is disseminated in the TEMP, TEMP MOBIL or TEMP SHIP code, with selected information distributed in the PILOT, PILOT MOBIL, or PILOT SHIP code.

- *RABAL observations (RAdiosonde BALloon):* These observations measure wind speed and direction by using a theodolite or a fire-control radar to track a reflector attached to a radiosonde train. When conducted in conjunction with a RAOB, data is distributed in the TEMP, TEMP MOBIL, or TEMP SHIP code. When only wind information is obtained, data is distributed in the PILOT, PILOT MOBIL, or PILOT SHIP code.

- *PIBAL observations (PIlot BALloon):* A balloon is tracked with an optical theodolite (or radar) to determine only low-level wind speeds and directions. No radiosonde is attached to the balloon. Heights are based on assumed ascension rates. When transmitted, data is encoded in PILOT, PILOT MOBIL, or PILOT SHIP code.

With the introduction of compact, computerized rawinsonde systems containing navigational aid (NAVAID) receivers in the mid 1980's, the Radiosonde and Rabal observations became obsolete. Pibal observations are still conducted by Marine Corps observers in the field to provide low-level wind observations in support of aviation operations and para-drop operations. Pibal observations are particularly important in situations where radio emissions would lead to detection by enemy forces.

Throughout the world, other countries conduct and transmit data from Radiosonde, Rawinsonde, Rabal, and Pibal observations. Several countries, including the United States, routinely carry out additional types of upper-air observations as follows:

- *Rocketsonde observations:* A rocket containing pressure, temperature, and wind sensors is launched from a ship, land station, or aircraft. After the rocket reaches apogee, the instrument package, deployed on a parachute, measures the atmosphere as it descends. Observed data is transmitted in the ROCOB code.

- *Dropsonde observations:* Aircraft deploy a parachute-carried sensor package; the sensors measure pressure, temperature, humidity, and winds. This information is transmitted in TEMP DROP code.

- *Aircraft flight level observations:* Aircraft flying routine flight levels may contain an automatic sensor unit that measures, encodes, and automatically transmits an Aircraft Meteorological Data Relay (AMDAR) message, which contains pressure, temperature, dew point, and wind information. Similar data may be gathered manually by the aircrew from onboard equipment and forwarded by voice radio or commlink in the CODAR code.

UPPER-AIR OBSERVATION PUBLICATIONS

All U.S. upper-air observations, including military, are governed by procedures outlined in the Federal Meteorological Handbook No. 3 (FMH-3), *Rawinsonde and Pibal Observations.* The FMH-3 prescribes federal standards for conducting Rawinsonde and Pibal observations, and for processing, encoding, transmitting, and archiving observation data. Also provided are procedures for quality control.

All information in the FMH-3 is consistent with World Meteorological Organization (WMO) standards. WMO publication number 306, Manual on Codes, Volume 1, *International Codes,* contains a complete breakdown of all upper-air observation code forms.

The following text discusses the Mini Rawinsonde System (MRS).

REVIEW QUESTIONS

Q1. Upper-air observations measure what two layers of the atmosphere?

Q2. Which atmospheric elements does a radiosonde measure?

Q3. What are the main uses of upper-air observation data?

Q4. What is the significant difference between a radiosonde observation and a rawinsonde observation?

Q5. What are the two types of upper-air observations still conducted by Navy and Marine Corps personnel?

Q6. An aircraft deployed radiosonde is known by what term?

Q7. What publication outlines procedures for all United States civilian and military upper-air observations?

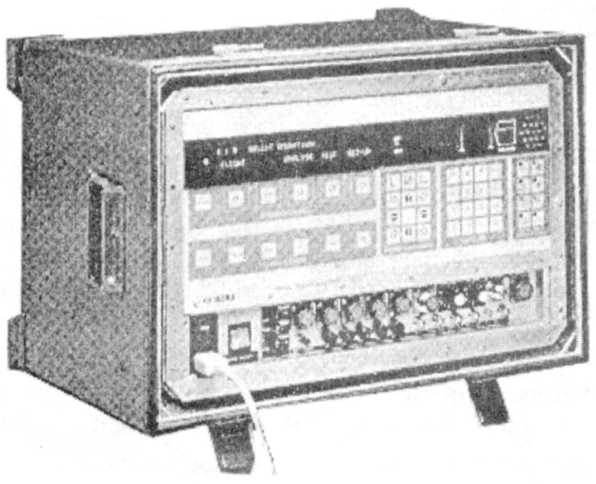

Figure 1-2.— AN/UMQ-12 MRS data receiver/processor and case.

MINI RAWINSONDE SYSTEM

LEARNING OBJECTIVES: Describe the procedures used to conduct an upper-air observation using the Mini Rawinsonde System (MRS). Explain the correct balloon preparation procedures. Identify the modifications that must be made to the MRS-evaluated data to conform to WMO international and regional coding requirements, as well as national requirements.

The AN/UMQ-12 mini rawinsonde system (MRS) is a highly compact, portable system ideal for shipboard, mobile team, and field use. It consists of a relatively lightweight (66-pound) computerized receiver/processor (fig. 1-2) mounted in a rugged, shock-absorbing case. The system also includes an RM-20 UHF telemetry antenna that receives data signals from the Vaisala RS-80 radiosonde transmitter, which is carried aloft by the balloon (fig. 1-3). Most MRS units are now equipped with a GPS antenna that is

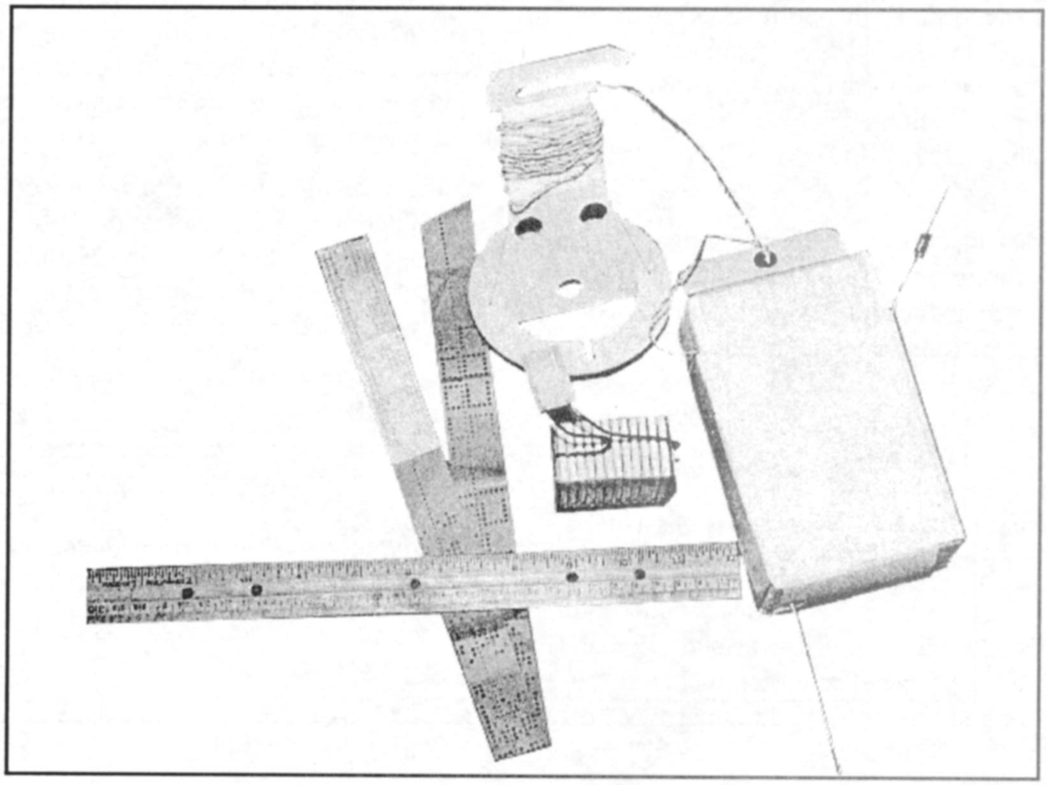

Figure 1-3.—Vaisala RS-80 series radiosonde instrument.

used to determine wind vector information from the radiosonde. Units without GPS use a VLF antenna to monitor reception of the OMEGA network NAVAID signals, which can be used to determine the same information. A printer is also included in the system.

The receiver can operate in nearly any environment on 110V or 220V alternating current, or on 24V direct current. However, make sure you keep the system sheltered from precipitation while in use. The VLF and UHF antennas should be mounted at least 8 feet apart. If working aboard ship, mount the antennas as high on the ships superstructure as possible, while avoiding radar antennas and other transmitters. In addition to equipment listed, a computer may be connected to the MRS for direct download of observation data to diskette. Data disks are then forwarded to the Fleet Numerical Meteorology and Oceanography Detachment (FNMOD), Asheville, North Carolina, for archiving. Figure 1-4 shows the overall operating scheme of the system.

MRS OPERATION

Operation of the AN/UMQ-12 is very simple and is detailed in the operator's manual, MWOP-00139-3.2,

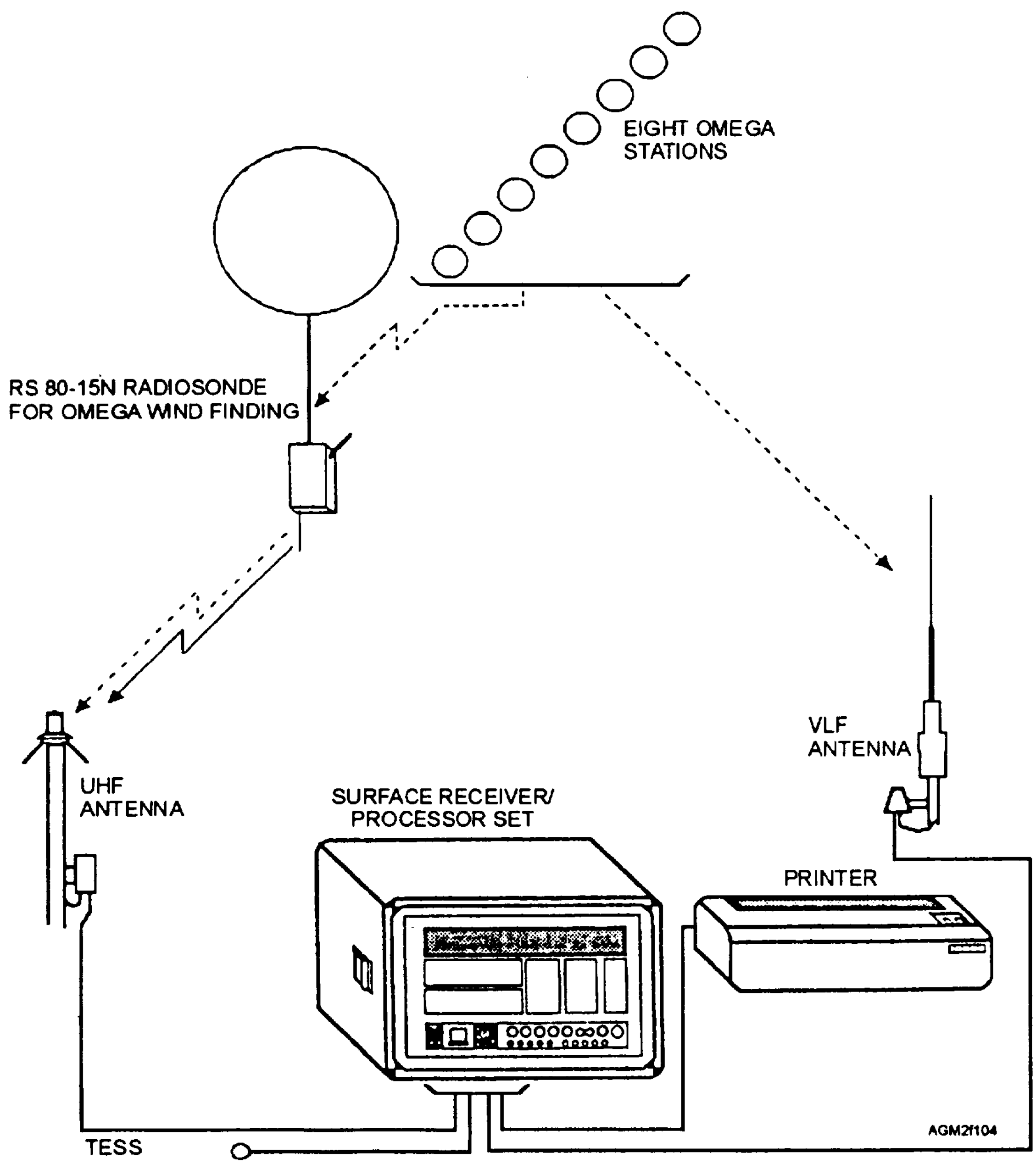

Figure 1-4.—MRS system diagram (VLF-Omega).

Mini Rawin System Operating Procedure, and the MARWIN MW 12, User's Guide. The display panel prompts the operator for input. The equipment should be left in the standby mode except when no soundings are to be taken for several days or when the system is to be moved. The system will automatically run self-diagnostic checks (after a brief warm-up period) when initially powered up. After self-diagnostics, the equipment will display the date and time (UTC). Initial setup parameters, such as station elevation, latitude/longitude, etc., must be entered by using the "SYSGEN" function. Operation control keys "CMND" and "C1" through "C5" are used to initiate or terminate data sequences. The LCD window directly above the operation control keys identifies the function of each key during each particular sequence. The data entry keypad is used to manually enter data.

To conduct an upper-air sounding, the operator normally runs through the following sequence, which is detailed in the operator's manual:

1. Preparation of the balloon
2. Preparation of the rawinsonde instrument and battery
3. Entry of rawinsonde calibration data
4. Rawinsonde telemetry and receiver check
5. GPS/NAVAID system signal reception check
6. Connection of rawinsonde instrument to balloon
7. Obtain release authorization
8. Balloon release (system automatically starts)
9. Surface weather observation and entry of data
10. Entry of termination data
11. Print out coded upper-air messages or data as desired (or download to diskette)

BALLOON PREPARATION

Preparation of the balloon is not covered in the MRS operator's manual. Certain aspects of balloon storage, handling, and release procedures are covered in the Federal Meteorological Handbook Number 3.

Meteorological balloons are spherical films of synthetic rubber (neoprene) that, when inflated with a lighter-than-air gas (helium or hydrogen), rise into the upper atmosphere. Sizes of balloons vary by application, but all are measured by the weight of the neoprene used to make the balloon. Meteorological balloons are extremely thin. The rubber is from 0.002- to 0.004-inch thick when inflated for release, but decreases to less than 0.00001 inch at bursting altitude. To state it more graphically, the balloon at release is thinner than an ordinary piece of writing paper, and decreases to 1/200th to 1/400th of its original thickness at altitude- a mere film of rubber. It is not hard to see that the smallest cut, bruise, or scratch sustained during preflight preparation is almost sure to cause the balloon to burst at a lower altitude. Careful preflight handling of these balloons is mandatory. Although meteorological balloons come in 100-, 300-, 600-, and 1200-gram sizes, we will consider only the 100-gram and 300-gram balloons.

The 100-gram neoprene balloons are recommended for normal MRS soundings and should be used during high-wind conditions. The 300-gram neoprene balloons are better suited for higher flights. Shipboard and MET users report average MRS soundings to the 130-hPa pressure level (about 48,000 feet) using unconditioned 300-gram balloons, and average flights to the 300- to 250-hPa level (32,000 feet) using unconditioned 100-gram balloons. However, the RS-80 series rawinsondes are designed for soundings in excess of 30 kilometers (well above the 25-hPa level) and routinely ascend above that altitude at most synoptic locations.

Balloons should be stored in their original sealed containers in a room isolated from large electric motors or generators. Motors and generators emit ozone, which is detrimental to neoprene. Ideal temperature for storage would be in the range of 10°C/50°F to 30°C/85°F. Temperatures below freezing and above 50°C/120°F should be avoided during storage. Balloons deteriorate with age; they should be used in the order of their production dates to avoid excessive aging. If by necessity balloons are stored at temperatures below freezing, they should be removed to a room having temperatures of 18°C/65°F or higher for at least 12 hours before use, to avoid any damage that would result if they were removed from the container and unfolded when cold. The balloons are extremely delicate, especially when softened by conditioning. No part of the balloon except the neck should be touched with bare hands. Use soft rubber gloves or soft cotton gloves, or use the plastic bag in which the balloon was received as a glove to handle any portion other than the neck of the balloon.

Balloon Conditioning

As a result of exposure to relatively low temperatures or extended storage, neoprene balloons lose a portion of their elasticity through crystallization. Balloons in this condition will burst prematurely. Conditioning the balloons restores their elasticity and helps ensure higher flights. Balloon conditioning should be done to all balloons more than 1 year old or that have been stored in cold temperatures. For Navy and Marine Corps observations, balloons may be conditioned by immersing the balloon in boiling or nearly boiling water for 5 minutes.

Balloon Inflation

Proper balloon inflation procedures are not published for the MRS system. The 100-gram and 300-gram balloons must be inflated so that the ascension rate keeps the MRS system active. Slower ascension rates may be interpreted as a leaking balloon, and the system will terminate the sounding. Faster ascension rates prevent accurate data sampling and may also result in automatic sounding termination by the receiver. The ideal ascension rate for a balloon is between 900 feet per minute and 1,000 feet per minute.

INFLATION GASES.—Helium is the safest lighter-than-air gas for use in inflating meteorological balloons. It is inert and will cause no fire, explosion, or health problems. Hydrogen or natural gas can be used in an emergency if helium is not available, but both gases are explosively flammable and pose serious safety hazards. Their use is not recommended. The AN/TMQ-3 hydrogen generator set has been used at some remote upper-air sites to produce hydrogen gas locally.

Two types of helium may be used to inflate balloons: oil-free and oil-pumped helium. Oil-free helium is supplied in metal compressed-gas bottles that are about 4.5-feet high; the bottles are painted gray, with the top portion of the bottle and valve cover painted yellow or brown. Since this gas is not hazardous to health, the bottle connection is a standard screw thread.

Oil-pumped helium, however, contains more contaminants than oil-free helium, and may cause health problems ifbreathed. These cylinders are painted gray with an orange band around the cylinder, and the cylinder connection has a reverse-screw thread.

The standard pressure-reducing helium regulator (fig. 1-5) is usually painted bright orange, and is used to regulate the flow of gas into the balloon. The regulator is attached to the oil-free helium bottles with an adaptor (on the chain). The indicator dial nearest the cylinder connection indicates total pressure in the helium cylinder (normally 2,000 psi when full) on the outer scale, and cubic feet of helium (220 cubic feet when full) on the inner scale.

The second indicator dial shows the low-pressure flow to the regulator outlet. The low-pressure flow is adjusted by turning the T-handle on the valve body; turning the T-handle clockwise shuts off the flow. Before the regulator is removed from the cylinder, the helium cylinder valve must be closed and the pressure bled from the regulator. A low-pressure hose is not supplied with the regulator. Several suitable low-pressure hoses are available through the supply system, but you may use a clear plastic, 3/8-inch-diameter hose that is lightweight and flexible. Use screw clamps to connect the hose from the regulator nipple to the inflation nozzle. Helium flow should be set during inflation at about 15 psi on the low-pressure gauge. Inflating balloons at higher settings will inflate the balloon too rapidly and stress the neoprene, resulting in premature balloon failure. Flow of gas into the balloon is controlled by the on/off valve on the weighted balloon nozzle.

INFLATING BALLOONS.—The ideal ascension rate for a 100-gram or 300-gram balloon is 900 to 1,000 feet per minute. This rate is achieved by inflating the balloon to neutral buoyancy (the balloon will neither rise nor sink on its own) while attached to an inflation nozzle weighted from approximately 600 to 1,000 grams (1.3 to 2.2 pounds). Before release, the weighted nozzle is removed and the 250-gram MRS RS-80 series rawinsonde instrument is attached to the balloon. A 100-gram balloon should have a free lift of about 600 to 800 grams, and a 300-gram balloon should have a free lift of between 800 to 1,000 grams.

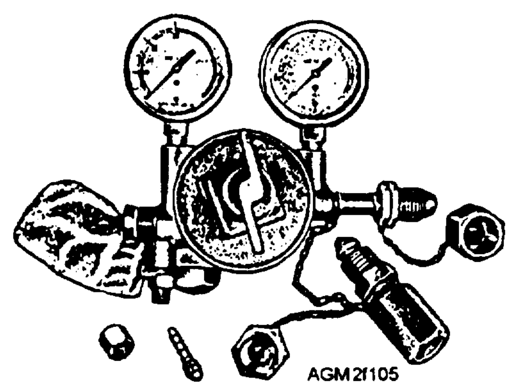

Figure l-5.—Standard pressure-reducing helium regulator.

To inflate a balloon, hold the inflation hose 2 to 3 inches from the connection to the balloon nozzle and allow the gas to flow into the balloon until the balloon just supports the weight of the inflation nozzle assembly (to achieve neutral buoyancy). It is a good idea to shut off the valve when the balloon is about half-full and listen for any leaking air from holes that may be in the balloon. Finally, shut off the gas flow and tie off the balloon.

If balloon inflation weights are not available, balloons may be inflated using only the regulator. You may inflate the balloons with the required amount of gas by using the inner (cubic feet) scale of the high-pressure dial. To achieve approximately 700 grams of free lift, a 100-gram balloon will take about 40 cubic feet of helium. To achieve 900 grams of free lift, a 300-gram balloon will need about 70 cubic feet of helium. In any case, the balloon should produce a fairly strong pull or tug on the nozzle and hose.

ADJUSTMENTS TO INFLATION.— Ascension rates should be calculated for all soundings. Because of environmental conditions, free lift weight is adjusted to better target the 900 to 1,000 feet per minute desired ascension rate. During precipitation or icing, you must increase the free lift to compensate for the additional weight of water, snow, or ice on the balloon. For example, during light rain or drizzle, you must increase free lift (weight of inflation nozzle assembly) by 100 grams or increase the helium in the balloon by 3 to 4 cubic feet. When light to moderate icing or moderate to heavy precipitation is anticipated, increase the free lift by 200 to 300 grams or increase the helium by 7 to 11 cubic feet. However, increasing the free lift by more than 300 grams during severe icing conditions may slow the ascent rate because of the increased surface area on which ice may collect.

Tying the Balloon

After inflation, it is imperative that the balloon neck be tied properly to prevent leakage of gas and to allow for attachment of the instrument. Most balloons can be sealed by using a single loop over the unwinder gripper and a plastic tie. If no plastic ties are available, use a 3- to 4-foot length of cotton textile tape (balloon tape) or a medium thickness cotton twine. Fold the twine in half to obtain a double thickness. While the balloon is still on the inflation nozzle, tie a tight square knot around the balloon neck about 1 1/2 to 2 inches below the body of the balloon. Remove the balloon from the nozzle and loop the excess balloon neck up and over the first knot by about an inch. Then, wrap the loop tightly with the remaining cord ends, and tie it securely with a second square knot. The loop in the balloon neck must be large enough to insert the gripper of the balloon winder through the loop (fig. 1-6). The remaining excess cord is used to handle the balloon before release. The balloon cord should be attached to the unwinder gripper with a double square knot prior to release. Tying the cord to the gripper will help prevent the gripper from chaffing the balloon loop during gusty wind conditions. Allow no more than 6 to 8 feet of train from the unwinder.

Use of Parachutes

Parachutes are neither required nor recommended for use during an MRS sounding. The 250-gram RS-80 series radiosonde instrument, even when in free-fall after balloon burst, has sufficient drag that even a direct strike to a person on the ground will cause no serious injury. However, the National Weather Service does require their use. If a parachute is elected for use at land stations, the parachute is tied to the balloon, and the radiosonde is affixed to the bottom of the parachute. Use of the 6-foot paper parachute or the 6-foot cloth parachute requires that an extra 100 grams be added to the nozzle weight during Inflation to maintain proper free lift. Meteorological parachutes are never used at sea.

Use of Balloon Shrouds

A balloon shroud is recommended for use to protect and securely hold or move the balloon and radiosonde prior to launch during windy conditions. The fabric balloon shroud may be used to hold balloons up to 7 1/2 feet in diameter. When moving a balloon, use the handles at the comers of the shroud. The cloth bands at the apex of the shroud may be used to attach an anchoring line, which is used to pull the shroud off the balloon as the handles are released during launch. Balloon shrouds must be hung to dry if used during rain, and must contain an antistatic electricity treatment if used with hydrogen or natural-gas-filled balloons.

REVIEW QUESTIONS

Q8. What is the purpose of the GPS antenna?

Q9. What are the two most widely used gases for meteorological balloons?

Q10. What are the two most commonly used meteorological balloons sizes?

Q11. What is the only part of the balloon that should be touched?

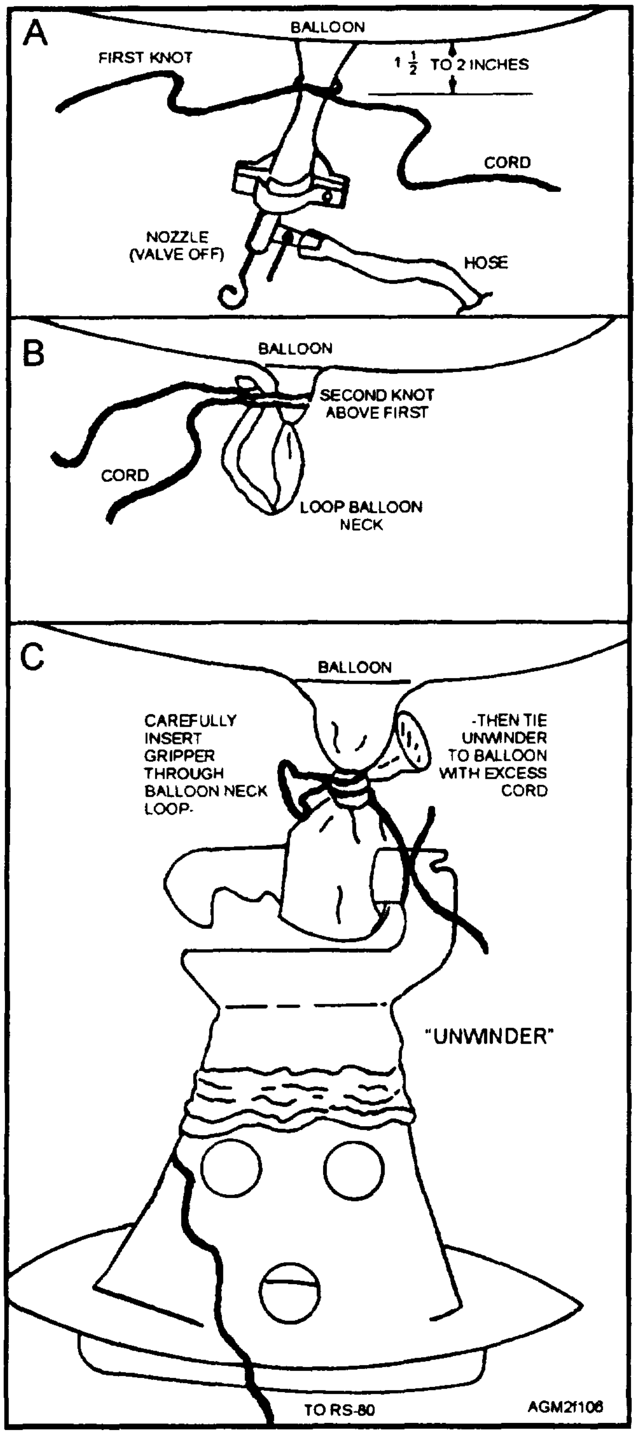

Figure 1-6.—Tying the balloon neck to hold the radiosonde instrument: (A) First square knot, (B) looping the balloon neck and tying the second square knot above the first, and (C) attaching the unwinder to the balloon and tying unwinder to balloon with excess cord.

Q12. Under what circumstances should a meteorological balloon be conditioned before use?

Q13. What is the ideal ascension rate for a meteorological balloon?

Q14. What is the purpose in using a gas regulator?

Q15. How much cubic feet of helium is required to achieve a free lift of 700 grams when using a 100-gram balloon?

Q16. What must be done to the balloon when conducting upper-air observations during periods of precipitation or icing?

Q17. At sea, when is a parachute required to be attached to the radiosonde?

Q18. What is the purpose of a balloon shroud?

PREPARATION OF THE RADIOSONDE

The lightweight, Vaisala RS-80 radiosondes are unpacked from the protective envelopes and readied for flight according to following the instructions provided in the operator's manual. An 18-volt battery is activated by immersion in room-temperature tap water for 3 minutes. After lightly shaking off the excess water, the battery is then plugged into the instrument to activate the radiosonde. The radiosonde instrument is automatically set to 403 MHz, but may be tuned from 400 to 406 MHz to avoid local interference. A small screw located on the outside of the radiosonde can be turned by using a small screwdriver to adjust the frequency up or down.

The radiosonde should be placed outside, out of direct sunlight and hot surfaces (decks/stacks), for five minutes. This allows the sensors in the radiosonde to stabilize prior to launch. Keep in mind that if the battery is left to sit for more than 20 minutes, it may overheat and become unstable, so time management of prelaunch procedures is essential. Be sure to remove the plastic cover from the sensor strip prior to releasing the radiosonde.

ENTRY OF CALIBRATION DATA

Each RS-80 radiosonde instrument is precalibrated during manufacture and is supplied with a calibration punch-tape. When each upper-air sounding is initiated, the system prompts the operator to enter the calibration punch-tape in the optical reader slot. This will ensure that the signals received from the radiosonde are properly interpreted by the system. The calibration coefficients printed on the nonperforated strip attached to the punch-tape may also be entered manually.

TELEMETRY AND RECEIVER CHECK

The receiver may be retuned to the radiosonde, following the procedures in the operator's manual, and the wide-band or narrow-band receiver mode selected. The wide-band mode is always used unless locally produced radio interference requires use of the narrow-band mode. Normally, both the radiosonde and the receiver should be retuned, to try to avoid the interference before selecting the narrow-band mode. The best reception of the radiosonde is indicated by five asterisks in the reception LCD window, with fewer asterisks indicating weaker reception. The absence of any asterisks indicates the signal is about to be lost.

NAVAID SYSTEM SIGNAL RECEPTION CHECK

Navigation-aid radio signal strength from the eight Omega stations are checked following procedures listed in the operator's manuals. If the receiver or transmitter is, or will move to within 60 nautical miles of one of the NAVAID transmitter sites, the receiver/processor will not process the signal properly and could cause incorrect wind data. The station must be deleted from the program before the sounding begins. Use the "SYSGEN" program edit mode as described *in* the operator's manual to delete a nearby Omega station. Upgraded MRS units and radiosondes use GPS, which is more reliable and accurate than the VLF-Omega system.

RELEASE AUTHORIZATION

After the instrument checks have been completed and the radiosonde is attached to the balloon, the operator must contact the air traffic controller in the shore-station control tower to obtain "permission to release a meteorological balloon." The air traffic controllers are responsible for transmitting any NOTAMs (Notice To Airmen) that may be required at Naval and Marine Corps air stations. Aboard ship, the operator must contact the officer of the deck (OOD) for permission to release a meteorological balloon. The OOD has the responsibility for contacting the Tactical Action Officer (TAO), the shipboard air traffic controllers, and the Air Boss to obtain release authorization, and then to relay the authorization to the observer. Since the shipboard process involves several different departments, each of which may be extremely busy with normal ship handling and flight-quarters evolutions, it is best to obtain authorization well before release time. Keep in mind that certain electronic emissions control (EMCON) restrictions may preclude a radiosonde launch.

SURFACE WEATHER OBSERVATION

Just before release of a meteorological balloon, a weather observation must be made. Data from the surface weather observation is entered into the receiver/processor either before or after release, but before the radiosonde instrument has passed the 14,000-foot height. The surface observation data entry routine will prompt the operator to enter the station pressure in whole hectopascals, the air temperature to the nearest 1/10 Celsius degree, the relative humidity to the nearest percent, true wind direction to the nearest degree, wind speed to the nearest knot, and the cloud group $N_hC_LhC_MC_H$, as described later in this chapter.

The surface observation data should be compared to the surface raw data received from the radiosonde and displayed by the computer. If the comparison values are outside the range plus or minus 1°C for temperature and 10% relative humidity, the radiosonde should be allowed to acclimate an additional 5 minutes. If the radiosonde fails this check, another radiosonde should be used.

BALLOON RELEASE

When the balloon is released, the radiosonde reports a decrease in pressure to the data processor, which automatically starts the data recording and processing function. Data will print out or be transmitted to a computer 8 to 10 minutes after release. During ascent through the first 15,000 feet, the radiosonde instrument is most susceptible to interference and loss of NAVAID/GPS signals used to determine winds. To determine accurate winds, the receiver should be maintained continuously in the "track" mode during this time.

REVIEW QUESTIONS

Q19. How are RS-80 radiosondes powered?

Q20. How can the radiosonde frequency be adjusted?

Q21. How is high quality reception indicated by the MRS?

Q22. Aboard ship, what person authorizes the release of a radiosonde balloon?

Q23. What should be done with the surface observation data before a radiosonde is released?

EVALUATION OF INFORMATION

Data is continuously monitored by the data processor during the sounding, with significant levels for temperature, humidity, and winds selected by the computer. The radiosonde readings will automatically print out in 5-second intervals in the first few minutes of the sounding, as shown in table 1-1, and then change to IO-second intervals.

All data are automatically processed. An increase in pressure is interpreted as a balloon burst, and the sounding will automatically terminate. Failure of the pressure to decrease is Interpreted as a "floating balloon," and this will also terminate the sounding. Other factors that will cause sounding termination are pressure values missing for more than 10 minutes, temperature data missing for more than 8 minutes, and humidity data missing for more than 6 minutes. Manual termination of the sounding may be made via the command entry keys.

CAUTION

Pressing the "reset" command at any time will completely dump all sounding data and reset the program to the beginning of the set-up routine.

All U.S. synoptic upper-air sites arc required to launch a second radiosonde should the first radiosonde fail to reach a height of at least 400 hPa. Navy and Marine Corps upper-air soundings conducted for operational support are exempt from this requirement. All raw data printed out during the flight should be scanned for validity. Continuous output of erroneous data will obviously necessitate another launch. Any periods of doubtful data should be encoded as such on the transmitted message. Prolonged periods of doubtful or missing pressure, temperature, humidity, or wind data may also Invalidate the sounding. Criteria IS outlined in chapter 3 of the FMH-3.

After the sounding is terminated, the system may be directed to print a listing ("LIST" program) of significant levels (table 1-2), which were selected by the computer for changes in temperature, humidity, or winds, and a listing of all mandatory levels (table 1-3). In addition, the "TEMP" program will produce a printout of the TEMP coded report (table 1-4). Abbreviations on the significant level printout indicate the reason the level was selected, such as *T* for temperature, *U* for relative humidity. *TR* for tropopause. *F* for wind speed, *D* for wind direction, and *MV* for maximum wind

Table 1-1.—-MRS Sounding Automatic Data Printout

Start Up Date 10 AUG 97 11:25 GMT

System test passed - No errors found

Sounding program REV 7.10 with Omega windfinding

Station : 02313

Location : 60.28 N 24.88 E 28 m above mean sea level

RS-number : 042873251

Started at : 10 AUG 97 11:48 GMT

Time min	s	Hgt/MSL m/MSL	Pressure hPa	Temp degC	RH %	Dewp degC	RI	MRI	Hgt/MSL ft/MSL	Dir deg	Speed kts
0	0	0	996.4	11.3	87	9.2	325	325	0	307	2.2
0	5	33	992.4	11.1	84	8.5	322	327	108	267	14.0
0	10	63	988.8	10.9	82	8.0	319	329	207	267	14.0
0	15	92	985.4	10.7	81	7.6	317	332	302	267	14.2

NOTE: Printout continues - every 5-10 seconds until end of sounding, @90 minutes

Table 1-2.—MRS Significant Levels Printout (LIST)

Time min	s	Hght gpm	Press hPa	Temp C	Hum %	Td C	RI	MRI			
0	0	0	996.4	11.3	87	9.2	325	325	T	U	
1	30	510	936.9	6.8	94	5.9	303	383	T		
6	35	2367	743.5	-5.7	95	-6.4	235	607		U	
6	50	2465	734.3	-5.9	77	-9.3	229	616		U	
7	55	2878	696.4	-9.1	96	-9.6	220	672		U	
12	35	4657	550.5	-20.8	79	-23.5	175	906	T		
12	55	4779	541.4	-21.9	83	-24.0	172	923		U	
14	20	5314	503.2	-26.0	58	-31.9	161	995		U	
21	30	8000	340.7	-49.6	54	-54.9	119	1375		U	
21	50	8135	333.7	-50.6	52	-56.2	117	1394	T		TR
23	35	8893	297.0	-51.7	21	-64.4	104	1500		U	
24	10	9166	284.8	-51.8	18	-65.7	100	1539	T		
26	0	9921	253.8	-46.4	3	-74.1	87	1644	T		
26	30	10125	246.1	-46.6	1	-81.4	84	1674		U	
29	25	11364	204.4	-43.9	1	-79.5	69	1853	T		
42	0	16117	100.0	-47.1	1	-81.8	34	2565	T	U	
48	30	18494	67.7	-50.5	1	-84.1	24	2928	T		TR
51	45	19719	57.8	-49.0	1	-83.1	20	3116	T		
54	15	20677	49.9	-52.8	1	-85.8	18	3264	T		
55	50	21277	45.5	-49.9	1	-83.7	16	3356	T		
58	10	22194	39.5	-53.3	1	-85.4	14	3498	T		
60	5	22943	35.2	-51.5	1	-84.8	12	3614	T	U	

Time mins	s	Hght gpm	Press hPa	dd deg	ff kts		
0	0	0	996.4	307	2.1	F	D
0	5	33	992.4	267	14.0	F	D
5	45	2037	775.4	281	10.3		D
8	0	2908	693.7	252	8.7		D
11	35	4276	579.4	254	11.1		D
14	50	5487	491.3	185	9.3		D
19	20	7135	388.1	155	6.0		D
20	5	7419	371.9	162	5.4		D
21	25	7963	342.6	212	4.5	F	
21	45	8100	335.5	226	4.9		D
23	35	8893	297.0	263	10.9		D
25	40	9787	259.0	281	23.5	F	
42	0	16117	100.0	270	31.3	F	D
60	5	22943	35.2	284	18.5	F	D

Table 1-3.—MRS Mandatory Levels Printout (LIST)

Press hPa	Hght gpm	Temp C	Hum %	Td C	dd deg	f kts	RI	MRI
1000.0	431	/////	///	/////	///	////	///	////
925.0	606	6.1	95	5.2	273	13.0	298	395
850.0	1303	1.5	85	-0.7	277	15.4	268	395
700.0	2837	-8.8	94	-9.6	254	8.6	21	666
600.0	5360	-26.4	58	-32.2	190	9.3	160	1001
400.0	6927	-40.1	50	-46.6	159	6.0	134	1221
300.0	8829	-51.4	23	-63.5	258	10.1	105	1491
250.0	10022	-46.3	2	-76.8	281	24.3	86	1659
200.0	11510	-44.5	1	-80.0	278	29.9	68	1875
150.0	13429	-45.7	1	-80.8	274	32.1	51	2160
100.0	16116	-47.1	1	-81.8	270	31.3	34	2565
70.0	18467	-50.4	1	-84.1	271	30.5	24	2924
50.0	20662	-52.7	1	-85.7	279	24.5	18	3262
30.0	23980	/////	///	/////	///	////	///	////

Significant Temperature and Humidity Levels

The following criteria apply to the selection of significant levels for temperature and humidity changes. They are considered mandatory and must be reported whenever observed. The MRS is programmed to automatically select these levels.

- Surface level and the highest level observed
- At least 1 level between 110 and 100 hPa
- Freezing level(s)
- The tropopause
- Bases and tops of all *temperature inversions* (layer in which the temperature increases with height) and bases and tops of all *isothermal layers* (layer in which the temperature does not change with height) that are 30-hPa or more thick and located below 300-hPa level or below the tropopause
- Bases and tops of all temperature inversions in which the temperature changes by 2.5°C or more below the 300-hPa level or the tropopause
- Bases and tops of all *humidity inversions* (layer in which the humidity or dew-point temperature increases with height) in which the relative humidity increases by at least 20% when located below the 300-hPa level or the tropopause
- Bases and tops for all layers thicker than 20 hPa in which temperature or humidity data is missing
- The bases and tops of all layers delineated as doubtful (must be entered manually)

The purpose of selecting significant levels is to ensure that the vertical profile of the atmosphere is accurately represented. When you plot significant levels on a diagram (such as the Skew T, Log P), connecting each plotted temperature and dew-point temperature with a straight line will provide a good representation of the actual temperature and moisture changes in the atmosphere.

The manual rawinsonde system operator must select levels based on the same criteria listed above in addition to other levels outlined in the FMH-3. As previously stated. the MRS automatically selects “mandatory” significant levels and “supplemental” significant levels to ensure that these criteria are met. But the MRS operator must review the selected levels to ensure that the system is operating correctly.

Table 1-4.—MRS Coded Message Printout (TEMP)

UUAA 65121 99603 10249 25004

99996 11221 30502 00531 ///// ///// 92606 06017 27513

85303 01422 27515 70837 08908 22509 50536 26556 19009

40693 40157 16006 30883 51562 26010 25002 46381 28024

20151 44586 28030 15343 45785 27532 10612 47185 27031

88334 50756 23005

77999=

(8 blank lines)

N N N N

UUBB 65120 99603 10249 25004

00996 11221 11937 06809 22828 00021 33744 05707 44734

05934 55696 09105 66551 20927 77541 21921 88503 26156

99341 49750 11334 50756 22297 51736 33285 51964 44254

46578 55246 46785 66204 43986 77101 47185

21212 00996 30502 11992 26514 22775 28010 33694 25009

44579 25511 55491 18509 66388 15506 77372 16005 88343

21004 99336 22505 11297 26511 22259 28024 33101 27031

31313 46105 81148 90155 RELEASE HGT: 45 FT.

41414 43322=

(8 blank lines)

NNNN

UUDD 65135 99603 10249 25004

70847 50584 27031 50066 53783 28024

88697 50584 27031

77999=

(8 blank lines)

NNNN

UUDD 6513/99603 10249 25004

11697 50584 22578 49184 33499 52983 44455 49984 55395

52383 66352 51583

21212 11352 28518

51515 10190 30398=

(8 blank lines)

NNNN

(information in italics may be inserted by the operator)

Significant Wind Levels

Significant levels are also selected for wind changes. When a sounding is evaluated manually, winds are plotted on either the Winds Aloft Graphing Board or the Winds Aloft Plotting Chart. Wind directions are plotted on a direction scale, and wind speeds are plotted on a speed scale. The MRS automatically evaluates winds and selects the proper significant levels. Some stations report Fixed Regional Levels for winds in place of significant wind levels.

FIXED REGIONAL LEVELS (WIND). Winds for the *Fixed Regional Levels* (table 1-5) must be reported by all designated Synoptic Stations in WMO Region IV, North America and Hawaii. This is a regional code convention. Current software in the MRS does not evaluate fixed regional levels, so they must be manually selected and encoded. This may be done by manually plotting the observed wind directions, wind speeds, and pressure for each minute of flight on a Winds Aloft Graphing Board or Winds Aloft Plotting Chart at the appropriate altitude. The pressure level, wind direction, and speed may then be determined for each fixed regional level. After the surface level, the first fixed regional level that is reported is the next higher level above the surface. When fixed regional levels are reported, additional significant levels may also need to be considered. In these cases, the MRS-selected significant wind levels are not used.

SELECTING SIGNIFICANT WIND LEVELS. Significant level winds are used by ships and MRS-equipped stations that are not required to report fixed regional level winds. The MRS uses the following WMO requirements when selecting significant wind levels:

- The surface and last level of the sounding
- The maximum wind(s)
- Any level of abrupt change in wind speed (greater than 10 knots) or direction
- The terminating wind (last wind speed of the sounding is greater than 60 knots and is the highest wind speed observed)
- Supplemental levels so that plotted wind directions at selected significant levels may be connected with straight lines and no direction (except in layers of winds less than 10 knots) will deviate by more than 10 degrees

Table l-5.—Fixed Regional Level Altitudes for Reporting Winds in WMO Region IV

UP THROUGH 100-hPa		ABOVE 100-hPa	
FEET	METERS	FEET	METERS
surface	0	60,000	18,000
1,000	300	70,000	21,000
2,000	600	80,000	24,000
3,000	900	90,000	27,000
4,000	1,200	100,000	30,000
6,000	1,800	110,000	33,000
7,000	2,100	140,000	42,000
8,000	2,400	150,000	45,000
9,000	2,700	160,000	48,000
12,000	3,600	170,000	51,000
14,000	4,200	180,000	54,000
16,000	4,800	190,000	57,000
20,000	6,000	200,000	60,000
25,000	7,500	etc.	etc.
30,000	9,000		
35,000	10,500		
50,000	15,000		

- Supplemental levels so that plotted wind speeds at selected significant levels may be connected with straight lines and no wind speeds will deviate by more than 10 knots

Stations that report only fixed regional level winds must also select significant level winds based on the criteria above, when applicable.

Supplemental Information

In addition to time, altitude, pressure, temperature, humidity, dew-point depression, and winds, the level printouts include *RI*, the refractive index in *N* units; and *MRI*, the refractive index in modified or *M* units. The Tactical Environmental Support System (TESS) uses M-units as the primary input for refractive effects analysis and forecasts.

MODIFICATION OF REPORT MESSAGE

The MRS coded message is in the proper WMO International code but does not conform to the United States national coding practice with regard to significant level winds. By national coding practice, all fixed and mobile land upper-air stations within the United States do not report significant wind levels, but only include fixed regional level winds. In addition, fixed regional level winds are reported in the PILOT code in message Parts B and D. However, U.S. Navy ships, even though they may be operating within WMO Region IV, report significant winds levels only in Part B of the TEMP code.

U.S. Naval ships may use Additional Data groups, the so-called "101-code groups" (table 1-6), as specified by WMO Region IV practice, even when operating outside the region. These codes must be used by all mobile and fixed land stations within North America, the eastern Pacific, and the Caribbean. These data groups are not encoded by the MRS, but must be manually entered. The 101-codes are used following the "51515" Regional Data Identifier group, as appropriate, in sections B and D of the TEMP codes.

Designated Synoptic stations use many of these 101 codes to indicate why a report for a scheduled sounding is not available at the normal time. Most Navy and Marine Corps upper-air observers use the code groups to explain the reason for sounding termination, to indicate levels of doubtful data, and to report corrected data. The FMH-3 contains a complete list of all 101 code groups. We will discuss where and how these codes groups are used within the TEMP code later in this chapter. In addition to the 101 codes, most ships insert the balloon release height immediately after the

Table 1-6.—Region IV Additional Data Groups

REASON FOR NO REPORT OR AN INCOMPLETE REPORT	**CORRECTED DATA FOLLOWS**
10140 Report not filed	10178 Tropopause data
10141 Incomplete report; full report to follow	10179 Maximum wind
10142 Ground equipment failure	10180 Entire report (parts to follow A, B, C, and D)
10143 Observation delayed	10181 Parts A and B
10144 Power failure	10182 Parts C and D
10145 Unfavorable weather conditions	10183 Parts A and C
10146 Low maximum altitude (less than 1500 feet AGL)	10184 Parts B and D
10147 Leaking balloon	10185 Minor error in this report. correction follows
10149 Military operations preclude sounding	10186 Additional significant levels not in original report follow
10150 Ascent did not reach 400 hPa level	10187 Surface data
10151 Balloon forced down by icing	10188 Additional data
10152 Balloon forced down by precipitation	
10153 Atmospheric radio interference	**DOUBTFUL DATA FOLLOWED BY ONE OR MORE OP$_n$P$_n$P$_n$P$_n$ GROUPS, FOR LOWER AND UPPER LIMITS OF DATA**
10154 Local radio interference	
10155 Fading signal	10165 Altitude and temperature doubtful
10156 Weak signal	10166 Altitude doubtful
10158 Flight equipment failure (radiosonde, balloon, etc.)	10167 Temperature doubtful
10159 Any reason not listed above	10168 Dew-point depression doubtful

last 101 code group. This allows other units to enter the sounding into their TESS system and recreate an accurate sounding profile.

REVIEW QUESTIONS

Q24. What causes an upper-air sounding to be automatically terminated by the MRS system?

Q25. What program in the MRS produces a printout of the significant levels?

Q26. What does the letter "U" indicate next to a significant level on the printout sheet?

Q27. What is the purpose of selecting significant levels?

Q28. What is the criteria for selecting a significant level wind based on direction?

Q29. Which activities in WMO Region IV do NOT report fixed regional level winds?

Q30. What do the "RI" and "MRI" columns indicate on the significant level printout sheet?

Q31. What is the purpose of the 101 indicator groups?

PILOT BALLOON (PIBAL) WIND OBSERVATIONS

LEARNING OBJECTIVES: Identify the procedures and equipment used to conduct PIBAL observations. Identify the computer software routinely used to evaluate PIBAL observation data.

Pibal observations during the 1940's through the 1960's were the primary method used to determine atmospheric winds, and the balloons were tracked as high as possible. Today, the primary application for Pibal-observed winds is low-level wind measurements for tactical fixed and rotary-wing aircraft operations, and para-drop operations. Although most naval units have little need to conduct Pibal observations, U.S. Marine Corps observers attached to Mobile Weather Support Teams and Recon Units routinely conduct mobile-land station Pibal observations during field operations and exercises. The collected information is normally distributed locally in plain language, and rarely encoded for electronic distribution.

A *PIBAL* is a balloon that is inflated with helium or hydrogen to provide a fixed free lift, which, in turn, produces a predictable ascension rate. It is tracked visually with an optical theodolite (an instrument used for measuring horizontal and vertical angles), with the observed azimuth and elevation angles recorded each minute. The height (AGL) of the balloon at each successive minute is based on a standard ascension rate for the size of the balloon. These ascension rates are listed in the FMH-3. When inflated properly to achieve a set free-lift weight, balloons are assumed to ascend at the standard rate, and true wind speed and direction are computed from the change in the horizontal position of the balloon.

PIBAL OBSERVATION PROCEDURES

The equipment and procedures required to conduct a Pibal observation are thoroughly described in the Federal Meteorological Handbook Number 3. Guidance on encoding Pibal-observed winds by land, ship, or mobile observers in International code (FM32-IX PILOT, FM33-IX PILOT SHIP, AND FM34-IX PILOT MOBIL codes) with the required Regional and National coding practices are contained in the FMH-3. Additionally, the basic International code is covered in WMO Publication 306, Manual on Codes, Volume 1, *International Codes.*

PIBAL EQUIPMENT

The equipment used to conduct a Pibal observation is fairly limited. You will need an ML-474 shore telescopic theodolite with an ML-1309 tripod (fig. 1-7) 30- or 100-gram balloons, a Universal Balloon Balance (PIBAL) weight set <u>or</u> the MK-216/GM balloon inflation nozzle and weight set, and a pressure-reducing helium regulator with hose. To evaluate the data, you will need either an appropriate calculator or computer and Pibal evaluation program, or you may use the manual method. The manual evaluation method requires the use of the MF5-20 Winds Aloft Computation Sheet, a set of "Balloon Distance Projected on a Curved Earth" scales (Horizontal Distance Out "HDO" scales) <u>or</u> a Horizontal Distance Computer (FCW-19) <u>or</u> an 18-C-58 PIBAL-RAWM calculator. An Aerological Plotting Board or Winds Aloft Plotting Board with the appropriate wind speed scale for the board, and a Winds Aloft Graphing Board or Wind Aloft Plotting Chart could also be used. The manual method is rarely attempted due to time requirements and the quantity and weight of the equipment. It has been replaced by the use of PIBAL software for hand-held programmable calculators and

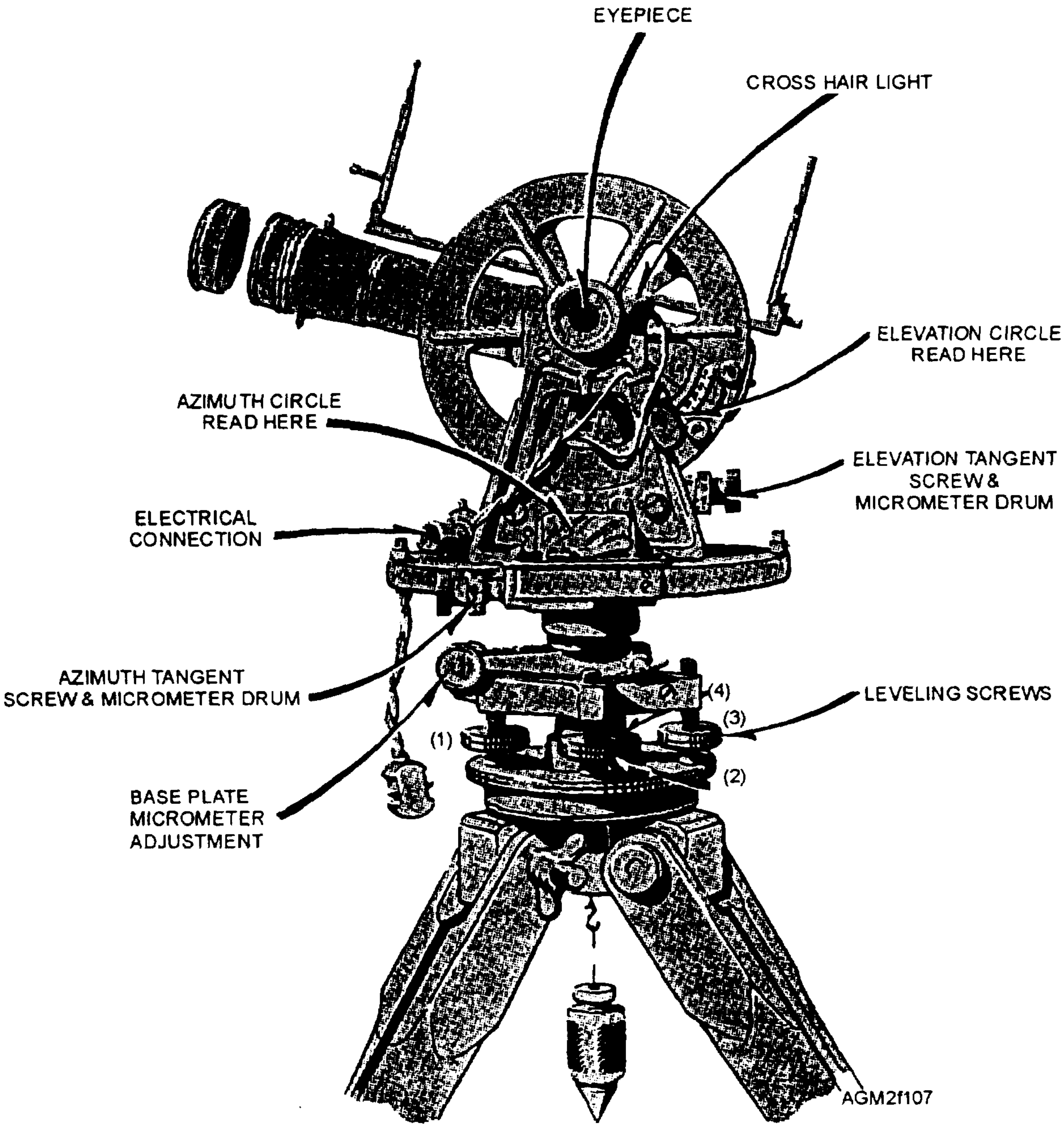

Figure 1-7.—ML-474 shore telescopic theodolite with an ML-1309 tripod.

desk-top computers available through the Geophysics Fleet Mission Program Library (GFMPL).

Theodolite

The theodolite is used to obtain the azimuth and elevation angles of the balloon. These angles are read to the nearest one-tenth of a degree. For use at night, a battery-powered lighting circuit illuminates both the azimuth and elevation scale. The theodolite telescope has an adjustable focus and must be refocused several times during the course of an observation. It also has a low-power setting for use early in the sounding, and a high-power setting for use when the balloon attains higher altitudes, The theodolite must be mounted on the tripod, leveled, and oriented to true north before use. Detailed guidance on the proper use, care, and storage of the theodolite is contained in the FMH-3 and AN 50-30WH-1, *Handbook of Overhaul Instructions with Parts Catalog for Theodolite AERO-1928-USN and Tripod AERO-1930-USN, and Signal Corps Theodolite ML-474 and Tripod ML-1309.*

CAUTION

The observer's eyes will be permanently damaged by looking directly at the focused sun image through the theodolite. Therefore, the observer must use extreme caution following the balloon while it is near the sun's angular bearing. and never track the balloon across the sun's disk.

Balloons

All pilot balloons are made of neoprene and are usually inflated with helium. A 100-gram balloon is used for a daytime scheduled Pibal that is expected to ascend 15,000 feet or more above the surface or during high-wind conditions. The 30-gram balloons are used for all other Pibals, including nighttime observations when equipped with a chemical light. The choice of color is to some extent a matter for the individual to decide. In general, white balloons are used with a clear sky; black balloons, with low or middle overcast, and red balloons, with high overcast. Usually, when haze, dust, or smoke is present in a cloudless sky, a white balloon remainsvisible longest. This is true because the sun shining upon it above a lower layer of haze creates scintillation— a twinkling or shimmering, which is absent when colored balloons are used.

Pilot balloons are inflated to achieve standard ascension rates. The 30-gram balloons are inflated with helium to neutral buoyancy while connected to the inflation nozzle weighted to exactly 139 grams (192 night). The 100-gram balloons are inflated with helium to neutral buoyancy while connected to the inflation nozzle weighted to exactly 515 grams (552 night). The length of cord used to tie the balloon neck is draped over the nozzle during inflation of the balloon. For nighttime observations, the additional weight of a chemical light is compensated for by hanging an unactivated light on the nozzle during inflation.

The initial ascension rate (216 ft/min for 30-gram and 350 ft/min for 100-gram balloons) slows gradually as the balloon expands. The height of either size balloon at any time is listed in the FMH-3, and is also printed on the MF5-20 Winds Aloft Computation Sheet. The computer evaluation programs calculate balloon height based on the time in flight. A surface wind observation must be taken no more than 5 minutes before release.

Lighting Units

Tracking a night Pibal is made possible by attaching a lightweight chemical light to the balloon. The lighting unit should be activated just prior to the release in accordance with the manufacturers instructions. You may use any color high-intensity chemical light, although green is most often used.

WIND EVALUATION

The GFMPL programs that evaluate Pibal winds only require the size of the balloon used and the consecutive minute readings of azimuth and elevation to determine wind speed and direction by the minute and/or in 1,000-foot (AGL) increments.

If the data is to be encoded for transmission, only standard pressure level and fixed level (or significant level winds) are reported. Pibal observations that do not extend to at least 1,000 feet are not transmitted. Guidance for the determination and selection of levels is contained in Appendix D and E of the FMH-3. These wind levels are determined after the consecutive minute or 1,000 foot winds are plotted on the Winds Aloft Graphing Board or the Winds Aloft Plotting Chart. Normally, 5 consecutive minutes of missing data will necessitate a new launch in addition to any equipment problems, such as a loose base clamp, etc. Missing data for less than 5 minutes may be interpolated. If severe or unusual weather exists in the vicinity of the observation site, a second verifying Pibal should be taken as soon as possible. After the observed data is plotted and evaluated, it is encoded in the PILOT code, as discussed later in this chapter.

Earlier in this chapter, we introduced the different codes used to relay upper-air observation data. We have briefly discussed the Mini Rawinsonde System observation procedures and indicated that the MRS automatically encodes the observed data in the appropriate form of the TEMP code. We have also mentioned that if Pibal-observed winds are encoded for relay, the PILOT code form is used. Although not every Navy or Marine Corps observer will have the opportunity to conduct upper-air observations, all will routinely use data contained in coded upper-air observation reports.

REVIEW QUESTIONS

Q32. What is the primary purpose of Pibal observations?

Q33. What instrument is used to track pilot balloons?

Q34. During a Pibal observation, how are true wind direction and speed computed?

Q35. Which publication contains detailed information on conducting Pibal observations?

Q36. What software package contains a program fur automatic computation of Pibal observation data?

Q37. What color Pibal balloon is normally used when the sky is clear?

UPPER-AIR REPORTING CODES

LEARNING OBJECTIVES: Recognize the applications for upper-air observation reporting codes. Identify the observation location and time in an upper-air report. Identify the standard upper-air observation times.

Upper-air codes are designed to allow transmission of a large amount of data using only a small number of characters. The numerically coded data allows the report to be decoded by a weather person in any country, regardless of the language spoken. More importantly, this numerically coded format can be readily transmitted by computer. These codes may be easily loaded into computer programs that analyze the upper-air data, plot graphical displays, and then calculate probable changes in the reported conditions. The resulting information serves as an invaluable forecast aid.

Reports of conditions measured during any of the various upper-air observations are normally encoded in WMO international codes for dissemination. International upper-air observation reporting codes were established by the WMO to allow all countries of the world to exchange data. Because there are many different types of upper-air observations conducted each day, several similar codes are in use to efficiently **report** the data collected. Table 1-7 shows the different types of upper-air observations conducted, the types of data observed and reported, and the WMO International code form used to format the report.

Reports received in these codes are routinely used by weather personnel for routine aviation support, weather-forecasting support, and as input for TESS. Additionally, these observations provide primary input to the Navy's environmental prediction system at the Fleet Numerical Meteorology and Oceanography Center, and to the National Weather Service's environmental prediction system at the National Meteorological Center. Navy and Marine Corps observers must be able to decode all upper air observation codes. And, as stated earlier, they must be able to encode, or verify, the MRS computer encoding of the various forms of the TEMP code.

IDENTIFYING MESSAGE CODE FORM

Nearly all coded upper-air-report messages contain a four-letter code identifier as the first group of the first line of data. All upper-air codes except the AMDAR code have a common format for the data identification line. As encoded for transmission, identification data appears in the first line of the message. The symbolic format for the identification data groups is as follows:

$\mathbf{M_iM_iM_jM_j\ \ YYGGI_d\ \ IIiii}$ (land stations)

or

$\mathbf{M_iM_iM_jM_j\ \ D.\ .\ .\ .D\ \ 99L_aL_aL_a\ \ Q_cL_oL_oL_oL_o}$
$\mathbf{MMMU_{La}U_{Lo}\ \ (h_Oh_Oh_Oh_Oi_m)}$
(ship/aircraft/mobile land stations)

The first group, $\mathbf{M_iM_iM_jM_j}$, is found in nearly every international coded report, and is the code identifier. The $\mathbf{M_iM_i}$ identifies the code type. See the second column of table 1-7. The $\mathbf{M_jM_j}$ identifies which part of the multi-part upper-air reports is contained in the section of the report: *AA* for Part *A*, *BB* for Part B, and so forth. If all of the observed data is routinely distributed as a single message, such as the CODAR report, the $\mathbf{M_jM_j}$ is encoded *XX*. The first group of the coded report also contains the observation time and the location of the sounding.

IDENTIFYING OBSERVATION TIME AND LOCATION

The WMO has established standard times for conducting upper-air observations: they are the synoptic hours of 0000Z, 0600Z, 1200Z, and 1800Z. Most balloon releases actually take place 30 to 45 minutes before these times so that the scheduled observation time actually occurs near the middle of the observation.

Because of time, personnel, and budget considerations, most stations do not conduct observations at each of the synoptic hours. If only two upper-air soundings are taken per day, they are taken at 0000Z and 1200Z. If only one upper-air sounding is conducted, it is taken at 0000Z or 1200Z, whichever time is closest to local sunrise.

Table 1-7.—Upper-Air Observation Types and Reporting Codes

WMO CODE	ID	OBSERVATION SITE	DATA	OB TYPE
FM 32-IX-PILOT FM 34-IX-PILOT MOBIL FM 33-IX-PILOT-SHIP	PP— EE— QQ—	Fixed Land Site Mobil Land Site Ship	Upper Wind Reports	PIBALs
FM 35-X-TEMP FM 38-X-TEMP MOBIL FM 36-X-TEMP SHIP FM 37-X-TEMP DROP	TT— II— UU— XX—	Fixed Land Site Mobil Land Site Ship Aircraft	Upper level Pressure Temperature Humidity Winds	RAWIN-, RADIO-, DROP-, SONDEs, and RABALs
FM 39-VI-ROCOB FM 40-VI-ROCOB SHIP	RRXX SSXX	Fixed Land Site Ship	Upper level Air density Temperature Winds	ROCKETSONDEs
FM 41-IV-CODAR	LLXX	Aircraft	Upper level Pressure Temperature Winds	Aircraft (manual)
FM 42-XI AMDAR	none	Aircraft	Upper level Pressure Temperature Dew point Winds	Aircraft to satellite data relay

NOTE: "—" indicates multi-part messages (AA, BB, CC, or DD).

The observation time is coded in the third group of the first line of data in the form **$YYGGI_d$**. This is the date/time group, with *YY* indicating the day of the month, and *GG* indicating the synoptic hour of the observation. The I_d is an indicator that is different in each code and will be discussed later.

On most reports received via telecommunications circuits, computers have already "read" the code identifier and date/time group and printed a message header at the top of the bulletin. A single bulletin may contain several Part A, TEMP SHIP, reports from different ships, all under a header such as UUAA 211200Z NOV.

The location where the observation was conducted is identified differently in the various code forms. Ship observations and mobile land-observation sites are located by latitude, longitude, and Marsden Square coordinates, which pinpoint the location. Established land stations are located only by referencing the international block and station number (IIiii) on weather plotting charts or in the *Master Weather Station Catalog.*

The identification groups "D. . . .D **$99L_aL_aL_a$ $Q_cL_oL_oL_oL_o$ $MMMU_{La}U_{Lo}$**" are used only by movable observation platforms to identify the observation platform and the location of the observation. All ships, mobile observation sites ashore, and aircraft use these groups. As in the Ship Synoptic code FM 13-X SHIP, discussed in module 1, the "D. . . .D" is the call sign of a ship or the call sign or communications identifier assigned to a mobile unit. The **"$99L_aL_aL_a$ $Q_cL_oL_oL_oL_o$"** groups are the latitude and longitude of the observation, exactly as used in the ship synoptic reports. The **$MMMU_{La}U_{Lo}$** group is a second location reporting group, which contains the Marsden Square number of the location, **MMM** (see Appendix II) and Marsden sub-grid locations **U_{La}** (a repeat of the units digit of the latitude) and **U_{Lo}** (a repeat of the units digit of the longitude). Some computers use only the Marsden group to enter the position of the upper-air report in the analysis program. The latitude and longitude groups are used by people to determine the exact location. Both groups must be correct.

In place of the latitude, longitude, and Marsden Square groups, permanent shore stations report only one group: **IIiii.** This is the WMO block (11) and station number (iii) exactly as used, and described in module 1, for the Land Synoptic code. Mobile land stations include an additional group ($h_Oh_Oh_Oh_Oi_m$) that reports the station elevation in either meters or feet.

The breakdown of all the different upper-air reporting codes and code formats is contained in the WMO Publication 306, Manual on Codes, Volume 1, *International Codes.* The majority of these coded messages are "read" automatically by computers and entered into analysis programs for use. In selected situations where manual decoding is required, the observer should consult WMO Publication 306. Both the TEMP code and the PILOT code forms are routinely used by observers to encode observed data. We will discuss these codes in the following text.

TEMP CODE

LEARNING OBJECTIVES: Identify the differences and similarities in the four forms of the TEMP code. Describe the information contained in each part of the TEMP coded report. Explain the format and the meaning of each coded part of the TEMP report. Describe the modifications added to the International code form in WMO Region IV. Describe the format and contents of an Early Transmission Message.

Although used by computers, the TEMP coded upper-air information is also used extensively in many manual applications. For detailed analysis, TEMP coded data is decoded and plotted on a Skew-T, Log P Diagram, or on horizontal or time section diagrams. The TEMP code is the primary upper-air reporting code. Every observer must be thoroughly familiar with this code.

The different forms of the TEMP codes are used to report data gathered in the rawinsonde, radiosonde, or rabal observations, depending on the site used to launch the balloon. However, aircraft-launched dropsondes use a slightly different code format. The four different forms of the TEMP code are listed in table 1-7.

COMPOSITION OF THE REPORTS (MESSAGE)

All four forms of the TEMP code are broken down into four parts to speed distribution. Additionally, each code part is divided into data sections. The data sections contain information in five-digit groups, although letters are used in one or two groups in the identification data section. Each figure in each group is significant to its position in the group and to its position in the message. Therefore, the established order of the groups in the messages must be maintained. When observed data is not available for an element, a slant (/) is used instead. This is done to preserve continuity of the groups and sections as required.

Message Parts

Each TEMP code part may be transmitted as an independent message. This is done to speed distribution of the reports, because a sounding usually takes a considerable amount of time. A radiosonde may continue to report usable data 2 to 3 hours after release. The parts are identified as A, B. C, and D. Data at and below the 100-hPa level is reported in Parts A and B, and data above 100 hPa is reported in Parts C and D.

Parts A and C contain data pertinent to the **standard atmospheric pressure surfaces,** which are also called the mandatory reporting levels. Parts B and D contain data pertinent to the significant levels. These are the levels that have been determined significant due to temperature and/or humidity change. and changes in wind speed or direction. The following diagram may help clarify what data IS included in each section:

PART A Mandatory Levels SFC to 100 hPa	PART C Mandatory Levels 100 hPa and higher
PART B Significant Levels SFC to 100 hPa	PART D Significant Levels 100 hPa and higher

All military stations designated to encode and transmit upper-air observations encode and transmit the

Early Transmission Message, and Parts A, B, C, and D. Each part of a code may be sent as a separate message as soon as the data is evaluated and encoded. The Early Transmission Message is manually composed while the first data levels are being received. Part A is available from the computer first, even while the observation of the higher levels is still being measured. Part B is available a short time later. Parts C and D are not available until after the upper-air sounding has been terminated. Many stations send each part as a separate message. Because of this, upper-air reports may be received in parts at different times after the synoptic hour.

With rapid electronic equipment, the number of messages, rather than message length, is often the key factor in speed of transmission. The MRS processor, when connected to a desktop computer or the TESS, rather than a printer, allows for formatted and completely composed messages to be delivered transmission-ready to the communications center. Whether all parts are included in a single message will depend upon a number of factors that change from day to day. When broken into separate sections, the Early Transmission Message has first transmission priority; Parts A and C have second priority; and Parts B and D have third priority.

Identification Data Section

Each part of TEMP code contains data for up to 10 code sections. These sections are not readily apparent in the coded message, and except for Section 1, Identification Data, the type of data that each section contains varies from part to part.

The identification data for each part of the code is nearly identical, and it is contained in the first line of each message part. We have already discussed the format of the identification data used with upper-air codes, and the "data type" identifiers for the different TEMP codes. Data type TTAA indicates a TEMP code report from a fixed land station (message Part A), while UUDD indicates a TEMP SHIP coded report from a ship (message Part D), and so forth.

The only difference in the identification data for the TEMP and the other upper-air codes is the indicator in the YYGGI$_d$ group, and the method used to encode the UTC date for **YY.** The TEMP code uses indicator $\mathbf{I_d}$ in message Parts A and C, but contains indicator $\mathbf{a_4}$ in Part B. In Part D, the indicator is replaced by a "/." The $\mathbf{I_d}$ is the indicator for the highest mandatory pressure level for which winds are reported (WMO code table 1734). If, for example, winds are reported to the 50-hPa level, the indicator as used in Part A would be "1," because Part A would include winds to the 100-hPa level; and the indicator in Part C would be "5," because the winds in Part C would be reported to the 50-hPa level. The $\mathbf{a_4}$ in Part B is a code figure for the type of measuring equipment used (WMO code table 0265), which should be reported as a 0 for the MRS system. The coding of the date, **YY,** identifies the wind-speed reporting units. If the wind speeds are reported in knots, as are all U.S. Military observations, 50 is added to the UTC day of the month. The 22d day of the month would be encoded 72. When the winds are reported in the standard meters per second, **YY** is simply the day of the month.

With the exception of the identification data, the data contained in each message part is the same for the different "TEMP" code forms. A TEMP report, a TEMP MOBIL report; a TEMP SHIP report, and a TEMP DROP report will all encode the same data using identical data formats.

REVIEW QUESTIONS

Q38. What is the purpose of the upper-air observation code?

Q39. What activity would use the FM 38-X TEMP MOBIL code?

Q40. What are the standard times for conducting routine upper-air observations?

Q41. If only one daily upper-air observation is required, what standard time should be selected?

Q42. How are ship locations identified?

Q43. Parts "A" and "C" of a TEMP coded message contain what type of information?

Q44. What is the purpose of an early transmission message?

Q45. What type of information would be contained in an upper-air message with the header "UUAA"?

Q46. In an upper-air message, when is 50 added to the date?

Q47. What does the information "TTAA 59121" indicate?

PART A - LOWER MANDATORY LEVELS

Part A of the coded message contains identification data, pressure, temperature, dew-point depression, winds, tropopause data, and maximum wind data. Table 1-8 shows the symbolic representation of the data in Part A, along with examples of coded data.

Identification Data

In the Identification Data section (section 1), example (1) shows typical coded identification data for a fixed land station 1200Z observation on the 14th day of the month from block 72, station 306, with winds in knots. Example (2) shows similar data for a mobile land station: 1200Z observation on the 14th day of the month from site 35.2°N, 078.7° W, Marsden Square 116, with winds in knots, and a station height of 100 feet. Example (3) is from a ship, the "NSHP" with a 1200Z observation on the 14th day of the month at 31.1° N, 072.1° W, Marsden Square 116, with winds in knots. Example (4) is an aircraft dropsonde directly over NSHP at the same time, except wind speeds are in meters per second.

Mandatory Level Data

The Mandatory Level data in section 2 contains the bulk of the coded data in this part of the report. The format for the surface data is slightly different from the format for the remaining mandatory atmospheric levels reported in Part A. The mandatory levels reported in this part are the surface, 1,000 hPa, 925 hPa, 850 hPa, 700 hPa, 500 hPa, 400 hPa, 300 hPa, 250 hPa, 200 hPa, 150 hPa, and 100 hPa.

For the surface, the three five-digit data groups report surface pressure, temperature and dew-point depression, and winds. For each of the mandatory levels, the three five-digit groups report the pressure

Table 1-8.—Part "A" TEMP Coded Upper-Air Report (Surface to 100-hPa Level Mandatory Reporting Levels)

SEC	SYMBOLIC FORMAT	CONTENTS
1	$\mathbf{M_iM_iM_jM_j}$ **YYGGI**$_\mathbf{d}$ **IIiii**	Identification Data
	Example:	
	(1) TTAA 64121 72306	(Land station)
	$\mathbf{M_iM_iM_jM_j}$ **D. . . .D** **YYGGI**$_\mathbf{d}$ **99**$\mathbf{L_aL_aL_a}$ $\mathbf{Q_cL_oL_oL_oL_o}$ **MMMU**$_\mathbf{La}$**U**$_\mathbf{Lo}$ ($h_Oh_Oh_Oh_Oi_m$)	Identification Date
	Examples:	
	(2) IIAA 64121 99352 70787 11658 01002	(Mobile-land station
	(3) UUAA NSHP 64121 99311 70721 11612	(Ship)
	(4) XXAA 14121 99311 70721 11612	(Aircraft)
2	99$\mathbf{P_0P_0P_0T_0T_0T_{a0}D_0D_0}$ $\mathbf{d_0d_0f_0f_0f_0}$ (surface)	Mandatory Pressure Level data
	$\mathbf{P_nP_nh_nh_nh_n}$ $\mathbf{T_nT_nT_{an}D_nD_nd_nf_nf_nf_n}$ (all other levels)	
	Example:	
	99030 05050 09015 **00**211 06060 09005 **92**353 02227 08021 **85**490 00646 07016 **70**010 06900 08527 **50**560 22764 09047 **40**718 33372 09045 **30**916 459// 09071 **25**090 543// 09096 **20**225 581// 09099 **15**475 595// 09615 **10**745 575// 09100	
3	88$\mathbf{P_tP_tP_tT_tT_tT_{at}D_tD_t}$ $\mathbf{d_td_tf_tf_tf_t}$ or 88999	Tropopause data
	Example:	
	88225 589// 09098	
4	77$\mathbf{P_mP_mP_md_md_mf_mf_mf_m}$ **(4**$\mathbf{v_bv_bv_av_a}$**)** or 77999	Max wind and wind-shear value
	Example:	
	77132 09628 40508	

level and the altitude of the level, temperature and dew-point depression, and winds. The three groups are repeated for each of the mandatory levels.

NOTE: In table 1-8. the subscripts used with each of the symbolic letters are the international symbolic format. The subscripts identify the level for which the data is being reported. such as the subscript "0" for surface, "1" for first level, "n" for any other level, "t" for tropopause level, and "m" for max-wind level. Although these subscripts are necessary when "looking up" the appropriate definition for a symbolic code letter in the International Codes manual, the subscripts make the code seem more complicated than it really is. We will ignore the subscripts used to identify the level in the remainder of this discussion on the TEMP code. Only significant subscripts used to define terms for other purposes are included.

SURFACE PRESSURE.—In the first of the three groups for surface information. the 99 is the indicator for "surface information" while the **PPP** is the hundreds, tens. and units of the surface pressure in hectopascals. In the example. 030 represents 1,030 hPa.

PRESSURE LEVEL ALTITUDE.—The first of the three groups for the remaining "mandatory levels" contains **PP.** the hundreds and tens digits of the reported pressure level, and **hhh,** the altitude in meters or decameters of the reported pressure level. For levels up to and including 700 hPa, the altitude is reported in three digits to the nearest meter with the thousands value, if any, deleted. For all levels above 700 hPa, the altitude is reported to the nearest decameter (tens of meters) with the ten-thousands value deleted. Refer to table 1-6 in module I, (Standard Pressure Surfaces) to determine the standard altitudes of the mandatory levels from the 1,000- to 10-hPa levels. For example. an 850-hPa level altitude of 1,457 meters is encoded 85457. To decode a reported altitude in Part A of 10711, the first two digits. 10, indicate the 100-hPa level. The 711 is the altitude in decameters, or "something-7,110 meters." Since the standard altitude of the 100-hPa level is approximately 16,180 meters (with the ten-thousands value of 1), one could correctly assume that the reported altitude is actually 17,110 meters.

TEMPERATURE/DEW-POINT DEPRESSION. —Following the surface-pressure group and the pressure-level/altitude groups, the next group contains the coded temperature and dew-point depression. The temperature is reported by **TTT$_a$.** The **TT** is the tens and units value of the temperature, in degrees Celsius. at the surface or the pressure level. The tenths value of the temperature is also used to indicate whether the reported temperature is positive or negative in the coded **T$_a$.** Zero, and all <u>even</u> "tenths values" in this position indicate a <u>positive</u> temperature. while an <u>odd</u> value indicates a <u>negative</u> temperature. When encoding, the tenths value is dropped to the next lower tenths value, if necessary, to indicate the proper temperature sign. For example, a temperature of -23.8°C is encoded 237, while a temperature of +23.9°C is encoded 238.

The radiosonde instrument measures temperature and relative humidity, and the MRS system (or observer) calculates the difference between the two instrument-reported readings when determining dew-point temperature. Only the *dew-point depression,* or the absolute difference between the air temperature and the dew-point temperature (with respect to liquid water), is reported in the TEMP code by **DD,** a coded figure. Dew-point depression (always an unsigned number), is normally calculated to the nearest tenth of a degree Celsius, and encoded using WMO code table 0777. Code figures 00 through 50 report dew-point depressions from 0.1°C through 5.0°C, respectively. Code figures 56 through 99 represent dew-point depressions rounded off to the nearest whole degree from 06°C through 49°C (subtracting 50 from the coded figure yields the dew-point depression in whole degrees).

WINDS.—The group **ddfff** is used to report wind direction and wind speed. The **dd** is the true direction in tens of degrees from which the wind is blowing. Observed wind directions are rounded off and reported to the nearest <u>5 degrees,</u> as specified by WMO regulations. The **fff** is the wind speed in hundreds, tens, and units. The units of speed are specified in the Identification Data section. For example, a wind from 275° true at 159 knots is encoded 27659; winds of 275° at 25 knots are encoded 27525, and winds of 270° at 25 knots are encoded 27025.

Tropopause Data

In table 1-8, tropopause data is contained in section 3 of message Part A, and may also be contained in Part C in the identical format. Tropopause data is only reported in the part of the message (A or C) that pertains to the level of the atmosphere in which the tropopause is located. The *tropopause level* is selected by the MRS system as the base of the layer in which the temperature stops decreasing with height or decreases very slowly with height, normally between the 250 hPa and 200 hPa level. Criteria on which the MRS system makes the selection is contained in the Federal Meteorological

Handbook Number 3. In some cases. there may be more than one tropopause. one below the 100-hPa level and the other above the 100-hPa level. In this case. both Parts A and C may report tropopause data.

Following the mandatory level data. three groups, **88PPP, TTT_aDD,** and **ddfff,** contain information very similar to the mandatory level information that pertains to the tropopause level. If the sounding did not locate a tropopause, the group 88999 is used in place of the data groups.

INDICATOR AND PRESSURE LEVEL.—The 88 is the indicator that tropopause data follows. The **PPP** is the pressure level. to the nearest hectopascal, at which the tropopause is located.

TEMPERATURE AND DEW-POINT DEPRESSION.—The **TTT_aDD** is the temperature and dew-point depression. encoded in the same manner as the mandatory level data.

WINDS.—The wind direction and speed. **ddfff,** are encoded in the same manner as the mandatory levels.

Maximum Wind

In table 1-8. section 4 contains information on maximum winds. Information on the highest winds observed between the 500-hPa level and the 100-hPa level, in excess of 60 knots. is contained in the Maximum Wind data group. Maximum winds located above the 100-hPa level are reported in an identical section in message Part C. Maximum wind data is reported in two or three groups. In the first group, 77 is the indicator for maximum wind. followed by **PPP,** the pressure level of the maximum wind to the nearest hectopascal. The second group. **ddfff,** contains the wind direction and speed. as preciously described. The third group. $4v_bv_bv_av_a$, is optional. and is used to report the absolute value of the vertical wind shear. The v_bv_b reports the vertical wind shear difference between the level of maximum wind and the winds 3.000 feet below the level of maximum wind, while the v_av_a reports the vector difference between the level of maximum winds and the winds 3.000 feet above the level of maximum wind. The vertical wind shear values are important indicators for clear air turbulence (CAT). The procedure to calculate vertical wind shear is discussed in the FMH-3.

When no winds in excess of 60 knots are observed between the 500-hPa level and the 100-hPa level. the group 77999 is reported. If two winds with identical wind speeds satisfy the criteria for a maximum wind, the levels will be encoded successively, beginning with the lowest altitude.

REVIEW QUESTIONS

Q48. How would the position of a ship located at 27.0N 152.0W be encoded?

Q49. What information is contained in Part A of the TEMP code?

Q50. Given the following: "85397 02659 24035." What is the altitude of this level?

Q51. When is 50 added to the dew-point depression?

Q52. How are mandatory pressure level winds reported?

Q53. How should the following information "70910 09163 33514" in Part A of a TEMP message be decoded?

Q54. What is the indicator for tropopause data in Part A?

Q55. How should the following information "77220 07602 40508" in Part A of a TEMP message be decoded?

PART B - LOWER SIGNIFICANT LEVELS

The second part. Part B of the TEMP coded messages (see table 1-9), contains data on levels that are considered significant because of changes noted in the temperature. humidity, or wind data. Although the significant levels are selected by, the MRS, you must verify the selection of significant levels. When the MRS processor selects levels, it first considers the mandator) significant level criteria. followed by the "supplemental" significant level criteria. Then, the MRS automatically encodes Part B. Remember however, some stations do not report significant wind levels.

Selection of Significant Levels

Proper evaluation of an upper-air sounding requires that the operator select significant levels when a sounding is conducted using manual equipment. The Mini Rawinsonde System automatically searches for and encodes significant levels. MRS operators must review and verify the computer-selected levels. In general. significant levels are selected with respect to temperature. humidity, and wind changes.

Symbolic Form of Part B

Part B (Table 1-9) consists of several sections of data. It starts with an Identification Data section (section 1), followed by section 5, data for each significant level selected with respect to temperature or humidity changes; section 6, data for significant levels selected with respect to changes in the wind direction or speed; section 7, sounding system data and observation time; section 8, observed cloud data; and ends with sections 9 and 10, regional and nationally coded data groups. Ship observations also report the sea surface temperature data in section 7.

Significant Temperature/Humidity Levels

Section 5 (Table 1-9) contains data for each level selected as significant for either temperature or humidity. Data for each significant level is contained in two five-digit groups, **nnPPP** and **TTTDD,** which are repeated for each significant level selected. The first group contains a level identifier, **nn,** and the pressure, **PPP,** of the level in hundreds, tens, and units of hectopascals. The level identifier is a two-digit number. The surface (and only the surface) is always 00. All remaining significant levels are identified, from lower to higher, as 11, 22, 33, . . ., 99, 11, 22, and so forth. If a level previously reported in Part A also fits the criteria for a significant level, it is reported again in this section as a significant level. The second group, **TTTDD,** is the temperature and dew-point depression, exactly as reported for the mandatory levels. Winds are not reported for these levels.

If temperature or humidity is missing, the top and bottom boundaries of the missing data layer are significant levels. At least one additional level must be selected within the layer of missing data. to indicate the missing data. The missing data is encoded with slants. For example, "55745 01522 66680 061// 77650 08310" identifies three significant levels. The base of a missing humidity layer, level 55, is at 745 hPa, with a temperature - 1.5°C and dew-point depression of 2.2°C. The top of the layer, level 77, is at 650 hPa, with a temperature of -8.3°C and dew-point depression of 1.0°C. The fact that the humidity data is missing in this layer is revealed by significant level 66 at 680 hPa, with a temperature of -6.1°C and "//" encoded in place of the dew-point depression.

Table 1-9.—Part "B" TEMP Coded Upper-Air Report (Surface to 100-hPa Level Significant Reporting Levels)

SEC	SYMBOLIC FORMAT	CONTENTS
1	**$M_iM_iM_jM_j$ YYGGa$_4$ IIiii** or Example: (1) TTBB 64120 72306	Identification Data (Land station)
	$M_iM_iM_jM_j$ D....D YYGGa$_4$ 99$L_aL_aL_a$ $Q_cL_oL_oL_oL_o$ MMM$U_{La}U_{Lo}$ ($h_Oh_Oh_Oh_Oi_m$) Examples: (2) IIBB 64120 99352 70787 11658 01002 (3) UUBB NSHP 64120 99311 70721 11612 (4) XXBB 14123 99311 70721 11612	Identification Data (Mobile-land station) (Ship) (Aircraft)
5	**$n_nn_nP_nP_nP_nT_nT_nT_{an}D_nD_n$** Example: **00**030 05050 **11**930 06040 **22**847 0043**33**770 02920 **44**650 10100 **55**600 1474**66**435 29769 **77**358 38170 etc.	Significant temperature and humidity levels
6	21212 **$n_nn_nP_nP_nP_nd_nd_nf_nf_nf_n$** Example: 21212 **00**030 13015**11**990 17022 **22**985 17035 **33**972 17015 **44**925 18005 **55**860 19015 **66**700 20025**77**550 22040 **88**320 23050 **99**300 23070**11**260 23112 **22**220 23090 **33**101 24060	Significant wind levels
7	31313 **$s_rr_ar_as_as_a$ 8GGgg 9$s_nT_wT_wT_w$** Example: 31313 46105 81135 90156	System status, time of launch, and Sea-water temperature
8	41414 **$N_hC_LhC_MC_H$** Example: 41414 43322	Cloud data
9	code groups following indicator groups 51515, 52525, through 59595	Regional codes
10	code groups following indicator groups 61616, 62626, through 69696	National codes

Significant Wind Levels

The beginning of section 6 may be identified in the coded message by the indicator group 21212. This section is used to report winds at "significant wind levels." All observers on U.S. Navy ships, Marine Corps, and naval upper-air observers operating outside WMO Region IV report significant level winds in this section, and need not report any information in the PILOT reporting code. Synoptic stations and other land or mobile land stations within WMO Region IV do not include this group in the TEMP coded report. Instead, the Fixed Regional Level Winds are reported using the appropriate PILOT code message Parts B and D.

Data for each significant wind level is contained in two groups of five-digit numbers, **nnPPP** and **ddfff,** which are repeated for each level selected. The first group for each level is used the same as in the significant temperature levels: it contains the level identifier **nn** and the pressure level **PPP.** The second group, **ddfff,** is the wind direction and speed. Encoding is the same as in part A of the code. Levels of missing wind data are reported similarly to missing significant levels of temperature and humidity.

System Status and Seawater Temperature

Section 7 (Table 1-9), 31313 $\mathbf{s_r r_a r_a s_a s_a}$ 8**GGgg** $\mathbf{9 s_n T_w T_w T_w}$, contains information on the rawinsonde system used for the observation, the actual launch time of the instrument, and the seawater temperature. The 31313 is the section identifier.

In the second group, $\mathbf{s_r r_a r_a s_a s_a}$**,** the $\mathbf{s_r}$ is the solar and IR radiation correction, found from WMO Code Table 3849. MRS systems use code figure 4, solar and IR radiation corrected automatically by system. The $\mathbf{r_a r_a}$ is the code for the rawinsonde system used and is obtained from WMO Code Table 3685. The current MRS system is reported by code 61 for the "Vaisala RS-80 Marwin." The $\mathbf{s_a s_a}$ is the tracking technique and system status, from WMO Code Table 3872. Code 05 is used with MRS equipment using VLF-Omega frequencies. GPS equipped systems will use code figure 08.

The actual UTC time of the radiosonde release is entered in the fourth group following the 8 indicator. If the radiosonde instrument is released at 1120Z, the group would read 81120.

The seawater temperature group is only reported by ships, and is deleted in reports from other stations. It is in the fourth group, which begins with the indicator 9. The s_n, the sign of the temperature (0 for positive and 1 for negative) is followed by the water temperature $\mathbf{(T_w T_w T_w)}$ in tens, units and tenths of a degree Celsius.

Cloud Data

Section 8 (Table 1-9) reports cloud information in one group following the 41414 indicator group. The $\mathbf{N_h C_L h C_M C_H}$ is the cloud group. The $\mathbf{N_h}$ is the sum of all the low-etage clouds present, or if no low-etage clouds are present, the sum of all the mid-etage clouds present, in oktas (WMO Code Table 2700), and **h** is the coded height above the surface of the lowest cloud layer (WMO Code Table 1600). The $\mathbf{C_L}$, $\mathbf{C_M}$, and $\mathbf{C_H}$ represent, respectively, the predominant type of low-, mid-, and high-etage clouds from WMO Code Tables 0513, 0515, and 0509.

Regional Codes

Regional codes are added to the international code following the regional code indicator groups. In WMO Region IV, the required regional codes are specified in the FMH-3. In Region IV, all regional data is reported in “additional” data groups, commonly called the 101-groups, following the 51515 Regional code indicator. Other countries may use different regional codes following any of the other regional code indicator groups 52525, 53535, . . ., 59595, and national codes 61616, 62626, . . ., or 69696. Regional and national codes for other countries are found in WMO Publication 306, Manual On Codes, Volume II, *Regional Codes and National Coding Practices.*

The 101 -groups are five-digit groups following the format 101 $\mathbf{A_{df} A_{df}}$. The $\mathbf{A_{df} A_{df}}$ indicates the type of data being reported as listed in table 1-6. Actual data may follow a "101-group" in additional code figure groups. Only data pertaining to the sounding below the 100-hPa level is reported with 101-groups in Part B. These groups can be used to report doubtful data, corrected data, or early transmission data. If the sounding terminates below the 100-hPa level, the reason for termination is also entered in this section.

PART C - UPPER MANDATORY LEVELS

Part C of the TEMP codes contains reports for mandatory levels above the 100-hPa level. The mandatory levels reported in this section are the 70-hPa, 50-hPa, 30-hPa, 20-hPa, and 10-hPa levels. This section uses the same format as Part A of the TEMP code message, including identification data, mandatory level data for the levels above 100 hPa, tropopause data (if located higher than 100 hPa), and maximum wind data (if located higher than 100 hPa).

If the upper-air sounding terminated below the 100-hPa level. Part C of the message may be encoded and transmitted including only the appropriate identification data followed by the code 51515 and the reason for termination code.

PART D - UPPER SIGNIFICANT LEVELS

Part D is used to report significant temperature and humidity levels, significant wind levels, and regional codes in the same manner as reported in Part B. Section 7, for sea-water temperature and the rawinsonde system information. and section 8. for cloud information, are never included in Part D. Coded regional information, such as the 101 -groups. arc included as appropriate for any levels above 100 hPa.

EARLY TRANSMISSION MESSAGES

Early Transmission messages are brief reports of certain observed upper-air data. which are sent as soon as possible after the radiosonde measures the 500-hPa level. Normally, these messages are manually encoded by all ships and designated synoptic land stations while the MRS continues to receive and process data. These messages contain only the appropriate Part B identification data, followed by, the code groups 51515 10196 and data for the 850-, 700-. and 500-hPa levels (as normally transmitted in Part A). Land stations may also include the stability) index and the low-level mean winds. The 10196 group identifies the data as an "early report.”

In addition to encoding Parts A through D of the TEMP code, certain stations must encode some data in the PILOT code, which is discussed in the following text.

REVIEW QUESTIONS

Q56. What Information is contained in Part B of a TEMP coded message?

Q57. What information is contained in section 8 in Part B of a TEMP coded message?

Q58. The 21212 indicator group is followed by what type of information?

Q59. How are boundaries of missing data encoded in Part B?

Q60. How should the following data "31313 46105 82325 90173" be decoded?

Q61. In what part of a TEMP coded message would you expect to find data for the 70-hPa level?

Q62. Early Transmission messages report information up to what level?

PILOT CODE

LEARNING OBJECTIVES: Identify the three forms of the PILOT code and explain the use of each form. Identify the type of information contained in each message part and the meaning of each coded element. Describe the special use of the PILOT code for Rawinsonde observations conducted within WMO Region IV.

The PILOT code is primarily used throughout the world to report PIBAL-observed wind directions and speeds. In the United States, it is also used to report fixed regional level winds observed during a Rawinsonde observation.

Like the TEMP code, the PILOT code is also separated into four parts to ease handling and speed transmission. Parts A and C include winds observed at the standard altitudes for the mandatory pressure levels. Parts B and D include winds for the significant wind levels. Parts A and B are for levels from the surface to 100-hPa (about 53,000 feet), while Parts C and Dare for levels above the standard 100-hPa level. Each part begins with an identification Data section.

There are three forms of the PILOT code prescribed for use by the WMO. WMO code FM 32-1X PILOT is used by designated shore stations to report upper-air observations of wind information. The code identifiers PPAA, PPBB, PPCC, and PPDD are used to identify this code form. FM 34-1X PILOT MOBIL is used by mobile sites ashore to report atmospheric wind observations. The code identifiers EEAA. EEBB, EECC, and EEDD are used to identify thiscode. At sea. shipboard upper-wind observations are reported in WMO code FM 33-1X PILOT SHIP using the identifiers QQAA, QQBB, QQCC, and QQDD. Each code form is nearly identical in format except for the identification information contained in the first line of each message part.

IDENTIFICATION DATA

The identification data contains the data type, the location identifier and/or location, and the date-time group. The format is identical to the TEMP code, Part B: $M_iM_iM_jM_j$ YYGGa_4 IIiii is used with the PILOT code, while PILOT SHIP and PILOT MOBIL use $M_iM_iM_jM_j$ D....D YYGGa_4 99$L_aL_aL_a$ $Q_cL_oL_oL_oL_o$ MMM$U_{La}U_{Lo}$ $h_Oh_Oh_Oh_Oi_m$. The same identification data format is used in all four parts of the report.

PART A - LOWER MANDATORY LEVELS

Part A of the message contains identification data; mandatory level winds. and the maximum wind and wind shear values.

Mandatory Level Winds

After the identification data. the first section of the PILOT code Part A is the winds at the mandatory levels in the format 44nP_1P_1 or 55nP_1P_1 ddfff ddfff ddfff. The 55nP_1P_1 group is used only when the altitudes of the pressure levels are based on standard altitudes above mean sea level. The 44nP_1P_1 group is used when the altitudes are obtained from pressure equipment. such as a radiosonde. This cluster of four five-digit groups, reporting winds at three mandatory levels, is repeated four times to include all the mandatory levels through the 100-hPa level.

In the first group. the *n* indicates the number of standard levels reported in the section and the number of ddfff groups that follow. This figure is usually a 3, but may be a 1 or 2 in the last repetition. The P_1P_1 is the hundreds and tens value of the first pressure level reported.

The ddfff group reports wind directions (dd) and wind speeds (fff). As in the TEMP code. the units of wind speed are meters per second if the date, YY. in the identification data is simply the UTC date. When the wind speed units are reported in knots, 50 is added to the date. All wind directions in the PILOT code are reported to the nearest 5 degrees.

For example. the coded groups 43300 09535 08058 06601 indicate winds at three pressure levels (from a radiosonde). starting at the 1,000-hPa level ("00"). 095° at 35 knots: the 925-hPa level. 080° at 58 knots; and the 850-hPa level. **065°** at 101 knots.

Maximum Wind

The following five different formats are used for the indicator group of the level of maximum wind or a secondary level of maximum wind:

66$P_mP_mP_m$—maximum wind at top of sounding, measured pressure level reported.

6$H_mH_mH_mH_m$—maximum wind at top of sounding. standard altitude reported in meters.

77$P_mP_mP_m$—maximum wind within sounding. measured pressure level reported.

7$H_mH_mH_mH_m$—maximum wind within sounding. standard altitude reported in meters.

77999—no maximum wind observed.

The $P_mP_mP_m$ is the measured pressure level in hectopascals and $H_mH_mH_mH_m$ is the altitude in decameters (units rounded off. hundred-thousands value not reported). A maximum wind level must have a wind speed in excess of 60 knots and occur above the 500-hPa level. A secondary maximum wind level may also be reported.

Following the maximum wind indicator group, the wind is reported in the format ddfff, and the optional vertical wind-shear group, 4$v_bv_bv_av_a$, may be reported the same as in the TEMP code.

PART B - LOWER SIGNIFICANT LEVELS

This part of the PILOT code message contains identification data, reports of winds at significant levels, and regional and national coded information for the levels up through 100 hPa. In WMO Region IV, the fixed regional levels (PPBB) replace any significant levels (section 6, Part B of TEMP Code).

Significant Level Winds

When only significant levels are reported. as indicated by the identifier group 21212. each level is encoded in two five-digit groups in the format nnPPP ddfff. The nn indicates the level (number 00 for surface, and then upward from 11 through 99, and repeating as necessary. The PPP is the pressure for the level. The ddfff is the wind direction and speed, just as reported for the mandatory levels.

Fixed Regional Level Winds

When this section is used to report winds at fixed regional levels, a slightly different format is used. The

21212 indicator group is not included. Winds are encoded in sets of three fixed levels, from lower to higher. Each set is preceded by an identifier group $9t_nu_1u_2u_3$ or $8t_nu_1u_2u_3$. Identifier groups beginning with a 9 are used when the fixed levels are separated by 300 meter (1,000 foot) increments, as used in WMO Region IV. An indicator "1" replaces the indicator "9" when the heights exceed 30,000 meters (100,000 feet). The "8" indicator means that the fixed levels are separated by 500-meter increments. The t_n is the tens digit of the first altitude reported in the set; the u_1, u_2 and u_3 are the units digits of the level number.

Essentially, as used by the United States, t_n is the ten-thousands value of the altitude in feet, and the u_1, u_2. and u_3 are the thousands value of the altitude in feet. For example, "91246 27575 27090 26606" indicates winds for the 12,000 foot (MSL), 14,000-foot (MSL), and the 16,000-foot (MSL) fixed regional levels, respectively, as 275° at 75 knots, 270° at 90 knots, and 265° at 106 knots. Refer to table 1-5 for a listing of the fixed regional levels used in WMO Region IV.

Regional Codes

Regional codes may be added to the report following the "51515" through "59595" group and national codes from "61616" through "69696" indicator group, as appropriate. In WMO Region IV, only the 51515 group is used. The Additional Data Codes or 101-groups, as discussed previously, may be added when encoding a Pibal observation. The indicator and the 101 -groups are not included when using the PILOT code Part B (or Part D) to report fixed regional level winds observed during a rawinsonde observation, since this would duplicate information previously transmitted.

PART C - UPPER MANDATORY LEVELS

Part C of the PILOT code is formatted exactly as Part A. Only the mandatory levels above the standard altitude of the 100-hPa level are reported in Part C.

PART D - UPPER SIGNIFICANT LEVELS

Significant level winds or fixed regional level winds for the levels higher than the 100-hPa level are reported in Part D. The format is exactly the same as Part B.

REVIEW QUESTIONS

Q63. What information is contained in Part A of the PILOT code?

Q64. What does the indentifier EEBB of the PILOT code indicate?

Q65. How would the information "44370 33030 35565 32082" be decoded from Part A of a PILOT coded message?

Q66. The group $77P_mP_mP_m$ is used to indicate what information in a PILOT coded message?

Q67. What is the minimum wind speed required for a wind level to be classified as a maximum wind?

Q68. When reporting fixed regional level winds in Part B of the Pilot Code. how would "90346 09012 10015 12520" be decoded?

Q69. What information is contained in Part D of the PILOT code?

OBSERVATION RECORDS

LEARNING OBJECTIVES: Identify the records that must be maintained by upper-air observers, and explain the proper disposition of these records.

SECNAVINST 5212.5, the *Navy and Marine Corps Records Disposition Manual,* identifies meteorological records, such as upper-air observations (except those conducted only for training), as permanent official records of the U.S. Government. As such, the original sounding records must be forwarded to FNMOD. Asheville, North Carolina, at the end of each month in accordance with NAVMET-OCCOMINST 3140.1, *United States Navy Meteorological and Oceanographic Support System Manual.* Duplicate copies of sounding records are temporary records that may be retained on board as long as they are useful, normally 1 year, and then destroyed.

PAPER RECORDS

When an upper-air sounding is conducted by using the MRS. the sounding records are considered to be the original printouts of the raw data, the printouts of the mandatory and significant levels (LIST), and the printout of the coded message (TEMP), including any operator entered data. The printout should be neatly folded in standard page size (8.5 by 11 inches) and mailed in a large envelope. DO NOT separate the continuous feed printer paper into individual sheets. Each sounding printout should be arranged in chronological order and identified with complete station identification and sounding identification information. Such information includes the following:

- Ship/mobile team/or station's name
- ICAO (shore), IRCS (ship)
- Mobile team or ship's latitude and longitude
- Elevation of release
- Scheduled observation time, day, month. year and actual time of release
- Radiosonde number
- Any remarks

Most of these items are automatically entered on the MRS printout.

DATA DISKETTE RECORDS

Every effort should be made to download upper-air observation data directly to floppy diskette for submission to FNMOD. Asheville, North Carolina. This is a much easier process. and the data is more rapidly archived. It also eliminates the storing of paper forms. Ensure the diskette is labeled with the data type (upper-air data). the station name and ICAO or IRCS. and the date/time of the data. Also ensure the disk is write protected.

Additionally, all upper-air observing units should maintain an *Environmental Meteorological Sounding (EMS) Log* file or book for all soundings. including training. The log should indicate. at the minimum. the instrument serial number. the data and time of release. the latitude and longitude. and elevation of release (for mobile units or ships), the size balloon used, how much gas was used to till the balloon, the altitude of the sounding at termination. the reason for termination, and the time it took the radiosonde to reach the termination level. Information about which Omega stations were used. the surface weather. and remarks may also be included.

Completed logs and duplicate copies of sounding records serve several useful purposes. They may be used for research or equipment evaluation, and as justification for budget requests.

REVIEW QUESTIONS

Q70. Where are upper-air observation records sent at the end of each month?

Q71. What information from an upper-air observation must be forwarded for archive purposes:'

Q72. What is the purpose of maintaining an Environmental Meteorological Sounding (EMS) log?

SUMMARY

In this chapter. we have discussed the different types of upper-air observations and the equipment in use by the Navy and Marine Corps. We also described the basic procedures for conducting Rawinsonde and Pibal observations. We then covered the two primary code forms used to report Rawinsonde and Pibal-observed information, and introduced you to the other upper-air reporting code forms in international use. Next, we explained how, by national practice. the United States reports fixed regional level winds in the PILOT code in addition to reporting the usual information in the TEMP code. Finally, we discussed the disposition of upper-air observation records.

ANSWERS TO REVIEW QUESTIONS

A1. The troposphere and the stratosphere.

A2. Pressure, temperature, relative humidity, and winds.

A3. Upper-air soundings are used as primary input to upper-air computer forecast products, as well as for climatological and atmospheric research. They are also used extensively for local forecasting,

A4. A radiosonde observation measures pressure, temperature, and relative humidity only, while a rawinsonde observation measures these parameters in addition to wind data.

A5. Rawinsonde and Pibal observations.

A6. A dropsonde observation.

A7. Federal Meteorological Handbook No. 3 (FMH-3).

A8. To determine wind vector information.

A9. Helium and hydrogen.

A10. 100-gram and 300-gram balloons.

A11. The neck.

A12. When the balloon has been stored in cold temperatures or is older than 1 year.

A13. Between 900 to 1,000 feet per minute.

A14. To reduce the pressure (flow rate) of a gas into the balloon in order to prevent damage to the balloon.

A15. About 40 cubic feet.

A16. Additional gas should be added to increase lift.

A17. Never.

A18. To protect and securely hold the balloon when launching in high wind conditions.

A19. With an 18-volt battery.

A20. The radiosonde frequency can be adjusted by using a small screwdriver to turn a tuning screw located on the outside of the radiosonde unit.

A21. By displaying 5 asterisks (* * * *) on the LCD.*

A22. The Officer of the Deck (OOD).

A23. The surface observation should be compared to the surface data from the radiosonde as a prelaunch check.

A24. A pressure increase or failure of the pressure to decrease, or long periods of missing data.

A25. The "LIST" program.

A26. The level was selected us significant due to changes in the relative humidity.

A27. To ensure an accurate representation of the vertical profile of the atmosphere at the time of the sounding.

A28. A wind direction change **of** *10 degrees or more provided the wind speed is greater than 10 knots.*

A29. U.S. Navy ships

A30. RI indicates refractive index values (N-units) and MRI indicates modified refractive index values (M-units).

A31. The 101 -indicator groups are used to report additive data such as the reason for termination, corrected data, and sections of doubtful data.

A32. To conduct low-level wind observations used for tactical fixed-wing and rotary aircraft operations, and paradrop operations.

A33. A theodolite.

A34. From the change in the horizontal position of the balloon, and then computed either manually by using a Winds Aloft Computation sheet and aplotting board, or automatically by using a calculator or computer program.

A35. The Federal Meteorological Handbook (FMH-3).

A36. Geophysics Fleet Program Library (GFMPL).

A37. A white balloon.

A38. The upper-air code allows a large volume of data to be transmitted internationally by using only a small number of characters. The code also provides for rapid evaluation of data through the use of computers.

A39. Mobile land sites

A40. At the synoptic hours 00Z, 06Z, 12Z, 18Z.

A41. The 00Z or 12Z synoptic hour, whichever is closest to sunrise.

A42. Using latitude, longitude, and the Marsden square number.

A43. Part A contains information on mandatory levels at and below 100 hPa, and Part C contains information on mandatory levels above 100 hPa.

A44. To transmit available information from the lower levels of the atmosphere prior to completion of the entire observation.

A45. Mandatory levels at and below 100 hPa from a ship upper-air sounding.

A46. When the wind speeds in ***an*** *upper-air observation are measured in knots.*

A47. The sounding is from a fixed land site. The date of the sounding is the 9th of the month at 12Z, and the wind speeds are in knots. Additionally, wind information is available to at least the 150-hPa level.

A48. 99270 71520 08872.

A49. Part A contains pressure-altitude, temperature, dew-point depression, and wind direction and speed data for all mandatory levels up to 100 hPa. It also contains tropopause and maximum wind data.

A50. 1,397 meters is the altitude of the 850-hPa level.

A51. When the dew-point depression is 6.0°C or greater.

A52. Wind direction is reported to the nearest 5 degrees and wind speed is reported to the nearest whole knot (or meter per second).

A53. The altitude of the 700-hPa level is 2,910 meters, the temperature is -9.1°C, the dew-point depression is 13, the wind direction is 335°, and the wind speed is 14 knots.

A54. 88.

A55. Maximum wind is at 220 hPa at 075° at 102 knots, the absolute value of the vector difference 3,000 feet below is 05 and 3,000 feet above is 08.

A56. Part B contains significant temperature and humidity levels. It also may also contain significant level winds, system status and observation time, sea surface temperature data, as well as cloud information and regional and national coded data groups.

A57. The observed cloud data.

A58. Significant level winds.

A59. At least one additional level must be encoded between the lower and upper boundary layers of the missing data.

A60. *So far and infrared radiation corrected automatically by the MRS; Vaisala RS-80 MARWIN system is being used as well as VLF-Omega frequencies. The radiosonde was launched at 2325Z, and the seawater temperature is 17.3°C.*

A61. *Part C.*

A62. *500 hPa.*

A63. *Lower mandatory wind levels and maximum wind data up to the 100-hPa level.*

A64. *Lower significant wind levels (or fixed regional wind levels) up to 100 hPa, reported by a mobile land station.*

A65. *The winds at 700, 500, and 300 hPa are 330° at 30 knots, 355° at 65 knots, and 320° at 82 knots. respectively.*

A66. *Maximum wind occurred within the sounding and is reported at a measured pressure level.*

A67. *61 knots*

A68. *The winds at the 3,000-ft. 4,000-f, and 6,000-ft levels are 090° at 12 knots, 100° at 15 knots, and 125° at 20 knots, respectively.*

A69. *Upper significant level or fixed regional level winds above the 100-hPa level.*

A70. *FNMOD, Asheville, North Carolina.*

A71. *All raw data, in addition to the mandatory and significant level data (LIST), and the coded message output (TEMP).*

A72. *EMS logs assist in research and equipment evaluation as well as budgeting considerations.*